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Report of Ad Hoc Expert Group on Technology Policies in Open Developing Country Economies

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PREFACE

This *Ad Hoc* Expert Group Meeting was convened in the context of resolution 33 (VIII) adopted at the eighth session of the Committee on Transfer of Technology, which requested the secretariat to examine the interrelationships among technology, trade, services, availability of financial resources and investment at the global level, particularly with resepct to the trade and development prospects of developing countries. The participants were invited by the Secretary-General of UNCTAD in their personal capacities.

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Introduction

1. The aim of the meeting was to assist the secretariat with its task of developing a framework for a better understanding of the set of policies which Governments of developing countries could adopt so as to accelerate their technological development and increase the international competitiveness of their economies.

2. The need for the convening of the *Ad Hoc* Expert Group on Technology Policy in Open Developing Country Economies was underscored by the growing amount of literature and empirical evidence on the role of technology in shaping international trade patterns and long-run growth, as well as on the scope for government intervention in building technological capabilities, particularly as regards the experience of a number of developing countries.

3. The background paper for the discussion consisted of a survey of "technology-gap" models of international trade. This survey had previously been commissioned by UNCTAD (UNCTAD/ITP/TEC/28). A brief summary of that study is reproduced in annex I. The *Ad Hoc* Expert Group Meeting focused on selected topics related to the specific nature of technology. The aim was to provide guidelines for the discussion (annex II). Written contributions from the experts are given in annex III. The list of the participants and their affiliation is given in annex IV.

I. Summary of discussion

A. Implications of technology-gap theories

4. The last couple of decades have witnessed a growing dissatisfaction, among both academicians and policy-makers, with the orthodox static model of trade which postulates that mutually beneficial trade between countries is driven by their different comparative advantages. According to this theory of the international trading system, a country specializes in the production and export of the good whose production uses intensively the relatively most abundant factor with which it has been endowed. According to the theory of comparative advantage, by increasing specialization, free trade increases the productivity of all countries and makes possible universally higher standards of living.

5. Given their resource endowments, it would be expected that less developed countries would export goods whose production requires a large labour input and that more developed countries would export goods produced with a relatively large amount of capital. Empirical evidence does not always support this hypothesis. Moreover, the theory does not adequately account for trade flows among countries with similar factor endowments (e.g., trade among OECD countries or South-South trade). Thus there has been a growing effort by the economists to develop pragmatic models which would better explain the observed trade patterns. The technology-gap models which assume a world of two countries, where one country innovates and the other country imitates, represent one such attempt. According to these models, both growth and trade are driven by technological change. Thus, if one country acquires knowledge about a more efficient way of producing a good, it will start exporting the good and continue to do so until the other country learns how to copy it and eventually starts producing it at a lower cost. One question that arises in this context is what are the implications of these models for government intervention to promote innovation and imitation, as compared with the standard theory. The relevance of this kind of general equilibrium model to developing country economies was considered by participants to be of particular interest to UNCTAD.

6. The experts felt that technology-gap models provided useful insights into the feedback mechanisms present in the innovation and imitation process that helps drive international trade. Like all theoretical constructs, it was noted that they also had their limitations. The extent to which the assumption of identical preferences could be used to explain trade flows among groups of countries having large discrepancies in levels of development was questioned. These models, like their more neo-classical counterparts, had not been specifically developed to provide policy guidelines and their welfare effects implications were not robust. Although imitation and innovation *per se* were both desirable, differences in the relevant costs associated with with these two activities could lead to different results in terms of welfare effects implications. These had to be evaluated before making policy prescriptions. Futhermore, the theoretical work that had led to the growing body of technology-gap literature was primarily aimed towards a better understanding of trade flows within developed countries and between developed countries and the newly industrializing countries. Hence there were limits in terms of policy formulation as a result of the underlying assumptions on which the models rested. Since, in the majority of developing countries, the constraint was lack of absorptive capacity relative to technology transfer, the scarcity of human capital and the underdevelopment of the technological infrastructure, the technology-gap models were not adequate for analysing these issues. With these limitations in mind, the role and the forms of government intervention in developing countries for promoting technological development were then discussed.

B. Market failures

7. The discussion on the extent of market failures has always been taken up in the debate concerning the welfare foundations of government intervention. Abstracting from the specific effects of technological progress, which are mainly dynamic in nature, the economic theory dealing with comparative efficiency, has been primarily concerned with market failures arising from indivisibilities, economies of scale, lack of information and imperfections in the capital and labour markets. It was generally agreed that the presence of externalities in the process of technological change and innovation was ubiquitous. However, the relative magnitude of market failures, both in developed and developing countries, needed to be assessed through further empirical studies. In this context, two points were stressed:

(a) The extent of market failures *per se* did not always justify government intervention. In a world where failures on the government side were also significant, it was necessary to compare the relative costs of intervention as opposed to a situation of non-intervention. If the intervention entrained additional distortions, the situation of non-intervention could yield superior welfare results;

(b) If the government assessed that there was a need to intervene, then the policies should be aimed at correcting the distortions at the source.

8. Generally, technology could produce various market failures, such as problems of appropriability, externalities related to learning, entry barriers due to large sunk costs involved in research and development (R and D) activities, risks associated with investment in human capital where there were long lags between the initial investment and the formation of a particular skill and risks stemming from the choice of technology, which led to lock-in effects. Although there was little conclusive empirical evidence showing that market failures were of greater consequence in developing countries than in developed countries, it was suggested that there were good grounds for believing that some types of failures (e.g., those linked to human capital formation) were of greater significance in developing countries, whereas other failures (e.g., those linked to innovative R and D) were more significant in developed countries.

9. It was stressed that, in a number of instances, the main obstacle to trade in developing countries was the underdevelopment or the non-existence of markets rather than defects in their functioning. In such a case, government policies ought to be directed towards the creation of markets through laws and regulations which encourage private initiative and facilitate the creation of new businesses, together with providing general economic infrastructure.

10. Finally, some kinds of market failures may be overcome through encouragement of international trade. An example would be that part of the benefits of R and D in other countries which can be realized through importation of the capital goods embodying the results of such R and D.

C. Extent of intervention

11. Views on the optimal extent of intervention varied greatly with the individual assessment of the competence of domestic bureaucracies in relation to economic policy implementation. Thus, economists who saw "government failure", i.e. mismanaged interventions, as having a potentially greater negative welfare effect than market failures, would argue that governments ought to provide the basic economic infrastructure, such as a communication network, education, etc., but avoid all other forms of interventions, thus allowing for the free operation of markets. According to this view, while markets do not operate perfectly, left on their own, they will nevertheless lead to superior welfare results as compared to the situation obtained with government intervention.

12. Noting that wrongly targeted government intervention can be very costly, some of the participants felt that there was no *a priori* reason to restrict government policies exclusively to the provision of infrastructure. Thus, it was argued, market failures related to technology were large enough to support the argument against the strict view of no intervention. The case of an

economy specializing in activities yielding low returns, and thus a slow pace of capital accumulation, was put forward as an example where government action could get the economy on a development path with a higher rate of capital accumulation and thus higher growth rates. Furthermore, it was stressed that static comparative advantage predicted poorly in any assessment of dynamic comparative advantage. Hence, governments might have to intervene by subsidizing activities which private agents might find unprofitable on the basis of current price signals.

13. It emerged from the discussion that the main problem related to the extent of intervention was identified one of feasibility, rather than theoretical desirability of government intervention. It was further stressed that governments might be constrained not only in intervening by the lack of competence in measuring the relative merits of policy action, but also by the lack of information about prevailing and future market conditions.

14. Finally, owing to lock-in effects arising from the choices made, the relevance of the timing of interventions was deemed an important element in determining the cost/benefit ratio of government action. It was argued that, in order to achieve optimal welfare results, government intervention ought to take place before any actual investment choice had been made by agents (i.e. an assessment of the future benefits of adopting a particular technology), as the costs of subsequent government action would increase with the time elapsed since the original choice had been made. An example of such types of problem was the selection of production technology by firms.

D. Forms of government intervention

15. Before opening the debate on various forms-*cum*-instruments of government intervention in the sphere of technology, the point was stressed that a necessary condition for implementing an operational technology policy was to provide a stable macroeconomic environment and to opt for an open trade régime. For a large number of developing countries, achieving those two objectives would already set them on a path of higher rates of growth and increased competitiveness. Once those preconditions had been met, government technology policy would then have an important impact on economic performance.

16. Market failures arising as a result of technological progress were related, as mentioned above, to the nature of knowledge creation and accumulation, the large investment costs and risks of R and D and the problems of appropriability. Since governments ought to try to correct such distortions at their source, tax-*cum*-subsidies policies and competition laws would be more efficient in solving the above-mentioned problems than trade policy. Even in cases where protection of domestic industry was the only feasible government policy, the temporary nature of this instrument should be emphasized as being the crucial prerequisite for its effectiveness. If the domestic industry were protected for an excessive period of time, losses on account of inefficiency in the production process and lack of competition were likely to outweigh the potential positive benefits accruing from the accumulation of technological capability. Moreover, an open trading system provided an efficient check on the creation of domestic oligopolies and their associated rent-seeking behaviour.

17. The general characteristics of all government policies, and thus technology policy, should be that:

(a) policies should be price-based rather than quantity-based so that exogenous shocks can be transmitted to the economic agents through price signals;

(b) policies should be generally "market-friendly", meaning that governments should supplement the functioning of markets when these are imperfect; sp0.5

(c) a large government involvement in terms of capital ownership (e.g., state firms) is not necessarily always desirable, because it tends to lead to inefficient decision-making by the economic agents and rent-seeking, and is frequently inconsistent with competitive behaviour;

(d) governments will always face a dilemma in judging the right amount of concentration *vis-à-vis* competition on the domestic market to optimize R and D activities. The government needs to find a solution which allows for some degree of industry concentration, permitting firms to appropriate the incurred costs of research, while at the same time avoiding

a monopolistic situation which yields no incentive for product or production process improvements;

(e) all policies (e.g., trade policy, industrial policy, etc.) should be mutually consistent, thus giving economic agents clear signals;

(f) for any policy, the credibility of government commitment to hold to the laid-out plan of action is necessary if the policy is to achieve its optimal effect. Moreover, the transparency of government policy, i.e. avoidance of *ad hoc* discretionary administration of regulations and the commitment not to be influenced by political pressures from various interest groups, will greatly increase its effectiveness;

(g) in a number of developing countries, there is a clear need to facilitate the process of setting up new firms because the present system of complex procedures for registering firms acts as an effective barrier to entry;

(h) with respect to the imperfections of capital markets, including underdeveloped markets, governments of developing countries should provide credit lines for viable investments, as well as financial insurance and risk-pooling in cases where the risks associated with an investment are too large to be taken up by any single economic agent;

(i) finally, with regard to trade policy generally, it is clear that in order to maximize the benefits from technological innovation, it is essential that all governments strive to maintain an open trading system.

E. Intellectual property protection, innovation and diffusion

18. "Trade-gap" models, including the ones reviewed above, in focusing on the innovation/imitation process, have tended to reinforce the view that under conditions of free trade the economic interests of the importers of technology (i.e. "the South") could be identified with conditions in which it is easy and inexpensive to "borrow" or copy new technologies, whereas the interests of "the North" were seen in these models as being linked almost exclusively to the generation of innovations. This view reinforces the long-standing notion that technology-borrowing developing countries are interested in weak regimes of intellectual property protection, and the technology-generating advanced countries in strong ones.

19. The experts felt that this notion was simplistic. There was another face to the North-South conflict. For example, the difficulties that the complementary role of tacit knowledge creates in successfully transferring codified technological information from advanced to developing countries would suggest that involving firms from the former countries via co-operative ventures and technology-support and training contracts would be in everyone's interest. While information asymmetries and monitoring difficulties make it virtually impossible to write efficient contracts specifying the transfer of tacit knowledge, it would be possible to design contracts for the successful implementation of technologies by bundling the provision of assistance together with the licensing of the use of codified information such as patents and copyrights. In such cases, it would be in the interest of technology importers to seek stronger protection for intellectual property, either through statutory measures, or judicial enforcement of trade secrecy rights as an incentive for attracting technology transfer.

20. Conversely, the case could be made for weaker protection for intellectual property in the North, which is not so monolithic as depicted in terms of technology generation. Technological progress is a cumulative process in which individual contributions build on each other, often with important synergic effects or unknown extensions. Strong measures protecting the intellectual property of a firm generating a given technology would place constraints on the ability of other firms to extend profitably, improve and integrate that particular technology into larger, more productive systems. It was pointed out that, in the case of complex technologies, strong enforcement of intellectual property was inhibiting the rate of technical progress in the North.

21. The desirability of a differentiated approach to intellectual property rights was put forward as an efficient solution to the current debate on this subject. It was stressed that tight intellectual property rights might be the optimal solution in industries which incur large R and D costs and

where the life-cycle of the product tends to be long. On the other hand, if the cost of the development of a new product was relatively low and its life cycle short, a loose intellectual property rights regime would be more efficient, as it would permit faster imitation without taking away the incentive for the original firm to engage in new innovation.

22. With respect to the domestic patent system, there were reasons to believe that "narrow" patenting and a large number of patents would produce superior welfare results, as it would cover specific parts rather than the whole of the production process, and would thus permit other firms to capture some segments of the production, leading to overall lower production costs. In contrast, broad patent protection would tend to limit the expansion of the stock of verified knowledge by monopolizing the development and elaboration of breakthrough innovations in the hands of the originating firm, which might lack either the incentive or the technical competence to pursue trade expeditiously.

23. Finally, it was stressed that, in the course of multilateral trade negotiations, the argument for a looser regime of intellectual property rights could be made stronger if it were based on efficiency rather than on equity grounds.

II. Concluding remarks

24. The participants voiced a need for more empirical research concerning "development-level-specific" technology policies: namely, identifying optimal forms of government technology policy at different stages of economic development. They felt that it would be useful to carry out case studies of national experience in the field of technological capability-building in a sample of developing countries, and then to analyse the reasons for the success or failure of various policies. Empirical work was needed in identifying the main obstacles to a faster pace of technological accumulation in developing countries. It was believed that a historical review of developed countries' experience could provide useful insights towards this end. Moreover, in designing country-specific policies, there was a need to carry out studies identifying the present domestic capabilities, and to choose appropriate intervention accordingly. Policies should be based on general principles which may serve as guidelines, but be adapted to the conditions and needs of each particular country.

ANNEXES

Annex I

TECHNOLOGY-GAP THEORIES OF INTERNATIONAL TRADE: A SURVEY

by A. Goglio

BRIEF SUMMARY OF THE STUDY

25. The survey represents an attempt to understand how technological choice is treated in the growth and trade theory literature. In particular, it has attempted to deal with the following two issues: first, what are the advantages of using technology-gap models of trade as compared to the orthodox Heckscher-Ohlin (HO) trade theory? Secondly, do these models depict the actual economic reality of the majority of developing countries?

26. The basic premise of the orthodox trade theory, where all markets are characterized by perfect competition, and where Pareto theorems hold, is rejected in the technology-gap trade models in favour of a more realistic view of market organization. In the HO model, trade is driven by the principle of a given comparative advantage in the production of some goods, which is determined by the relative factor endowments prevailing in each economy. A country specializes in the production of goods which use the relatively abundant factor intensively and imports those goods which use the scarce factor intensively, thereby producing a superior welfare outcome as compared to the situation with no trade. However, the HO theory has been criticized for failing to explain a number of salient features of international trade flows. First, it fails to explain the reasons for the existence of intra-industry trade among countries. Secondly, it has not been able to account for the fact that some countries export goods which use the scarce factor intensively. Thirdly, it predicts an equalization of factor prices across countries, which is not supported by the empirical evidence.

27. The study contains an analytical discussion of what is generally considered the technology-gap (TG) theory of international trade, from early contributions to most recent developments. The TG theory can be divided into four different strands: ***Krugman-Vernon; Trade, Innovation and Growth in TG; Ricardian TG***; and ***Generalized TG***.

28. Despite a different degree of complexity, all contributions in the first two strands build upon Krugman's (1979) model.[1] The remaining strands can be regarded as separate entities.

29. Krugman (1979) offered the first comprehensive formalization of Vernon's (1966)[2] international trade and investment "product cycle" theory. It is a simple dynamic North-South technology transfer model with different types of commodities. Both innovation and imitation processes are exogenously given. Labour is the only factor of production.

30. Subsequent works which constitute the Krugman-Vernon strand have endogenized technological change and or incorporated other more realistic assumptions. For instance, improvements are studied via the introduction of a non-trading sector, the allowance of two factors of production, and so on.

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1 Paul Krugman (1979), "A model of innovation, technology transfer and the world distribution of income", *Journal of Political Economy*, vol. 87.

2 Raymond Vernon (1966), "International investment and international trade in the product cycle", *Quarterly Journal of Economics*.

31. The second strand, "Trade-innovation and growth in TG", has been developed recently in the joint works of Grossman and Helpman and may be viewed as a highly sophisticated refinement of the Krugman-Vernon approach. In addition, Grossman and Helpman have incorporated what is presently characterized as the "New theory of growth" into the Krugman-Vernon approach. Accordingly, learning, knowledge-accumulation and trade flows are key sources of economic growth, a process that can be sustained in the long run. Models fitting the above two strands are also called "discrete models", as they assume a number of goods without specifying the complexity of the technology needed to produce them. However, this type of information is the key feature of the remaining two strands, which assume a continuum of goods of increasing technology intensity.

32. These models (Ricardian TG and Generalized TG) rely heavily on previous works by Dornbusch, Fischer and Samuelson (1977)[3] and Wilson (1980),[4] even though they have unambiguously different origins and goals. Ricardian TG models build upon the formal Dornbusch *et al.* (1977) Ricardian comparative advantage model and aim at providing the TG correlate of that work. Generalized TG is based on the "economic theory of technical change" developed by the heterodox economists of the University of Sussex (United Kingdom). This strand's aim is the design of a TG model general enough to cover a large range of commodities with different technological characteristics.

33. TG models in general have attempted to deal with a number of the shortcomings that the orthodox theory failed to overcome. The TG theory assumes a two-country world, where the North innovates and the South imitates. Innovations can either take the form of inventing new products or new production techniques, and technological progress in general occurs in an imperfectly competitive world of the Chamberlin or Schumpeter type. Technological change is treated as an endogenous process related to the firm's decision-making and thus marks a strong departure from the neo-classical theory wherein technological progress is treated as an exogenously-given variable. By introducing a demand function, which assumes that consumers have a preference for variety, TG models can account for intra-industry trade in a world of monopolistic competition.

34. Thus, while some firms invest in R and D and innovate, other firms imitate the product and start producing it at a lower cost, which then pushes the technological leader to invent a new product, so as to preserve some monopolistic rent, until it in turn is copied by the imitator. This process of innovation and imitation drives both trade and growth. Moreover, since the models assume a discrepancy in the price of factors across countries (TG models usually assume a single factor-labour, thus the South is assumed to have lower wage rates than the North), they can explain why we do not observe a convergence of factor prices in the long run. However, TG models have a few drawbacks with regard to their applicability. Since they have been constructed with the purpose of explaining trade among countries at a similar development level, they may not be well suited for explaining trade between the industrialized North and the developing South. First, the assumption of an identical demand function for all countries may not be appropriate if consumers in the North and South do not have the same set of preferences. Secondly, all TG models assume the *a priori* existence of an imitative capability in the South. This assumption might be relevant for a few developing countries (e.g., the East-Asian NICs), but is unlikely to be applicable to a number of other countries. This becomes a problem when "South" is intended to refer to all developing countries. How the potential for imitation can be generated and what types of structural problems the South needs to overcome in order to become an imitator are completely excluded issues. As a result, the range of developing countries fitting TG models is limited to a very small subgroup.

35. Despite their shortcomings, TG models have succeeded in rigorously formulating the long existing intuition that technological progress is a major contributor to the comparative advantage

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3 R. Dornbusch, S. Fischer and P. Samuelson (1977), "Comparative advantage, trade and payments in a Ricardian model with a continuum of goods", *The American Economic Review*, December.

4 Charles Wilson (1980), "On the general structure of Ricardian models with a continuum of goods: applications to growth, tariff theory and technical change", *Econometrica*, vol. 48.

of firms and nations. The new theory on long-run growth (Romer, 1986; 1990;[5] Lucas, 1988;[6] Becker and Murphy, 1988[7]), which has assigned a central role to human capital formation as a means for sustaining development, has contributed to the development of the technical instruments to model the above intuition. Future work on trade theory could therefore focus on the structural constraints on the accumulation of human capital, since it is one crucial endowment a developing country needs to build up in order to become a potential imitator. Better knowledge of this process could help in understanding why most developing countries are still barred from imitation.

5 Paul Romer (1986), "Increasing returns and long-run growth", *Journal of Political Economy*, vol. 94; Paul Romer (1990), "Are non-convexities important for understanding growth?", *The American Economic Review*, May.

6 R. Lucas (1988), "On the mechanics of growth", *Journal of Monetary Economics*.

7 G. Becker and K. Murphy (1988), "Economic growth, human capital and population growth", prepared for the Institute for the Study of Free Enterprise System, *Exploring Economic Development through Free Enterprise*, University of New York, May.

Annex II

AD HOC EXPERT MEETING ON TECHNOLOGY POLICIES IN OPEN DEVELOPING COUNTRY ECONOMIES

UNCTAD, Palais des Nations, Geneva

5 and 6 December 1991

ISSUES FOR DISCUSSION

36. The aim of this meeting is to assist the UNCTAD secretariat in its long-term task of developing a framework for a better understanding of the set of policies that governments of developing countries could adopt to accelerate their technological development and increase the international competitiveness of their economies. Although technology-gap models provide useful insights into the determinants of international trade, they appear to be less useful in providing policy guidance. Taking the review prepared for UNCTAD by Alessandro Goglio as a point of departure, the meeting will focus on the appropriate forms of government intervention.

37. Owing to the vastness and specialized nature of the subject, we have elected only what we have perceived to be some of the most important issues as the subjects of our discussion. Needless to say, if the participants feel that some very important issues are left out, they are welcome to introduce them.

A. Technology-gap trade models

Topic I: ***Implications of technology-gap theories***

38. Technology-gap models depict a two-country world, where the technology leader (the North) innovates and the follower (the South) imitates. A higher rate of imitation increases the exports from the South and spurs greater innovation in the North, thus producing overall positive welfare effects for both trading partners.

(1) The experts are invited to consider whether the notion of dynamic comparative advantage that drives these models implies a greater scope for developing country government intervention than ordinary static comparative advantage. If so, how? If not, why not?

(2) The background paper has suggested that the majority of developing countries may not belong to the definition of the South, as described in the technology-gap literature, because they lack the "qualifications" to be imitators. Do the experts agree and, if so, to what extent, if at all, do they believe that these kinds of models can be made to accommodate learning to imitate?

B. Policy issues

39. The argument for industrial policy draws from the perception that uninhibited operation of the price system does not suffice to ensure socially optimum investment in the accumulation of technology. Therefore, the argument goes: governments must intervene in order to deal with market failures arising from various imperfections in product and factor markets, substantial economies of scale, large fixed costs of entry, steep learning curves and potential externalities associated with these and other phenomena such as R and D, investment in human capital and an assortment of unpriced horizontal and vertical linkages that may exist between firms and between industries.

Topic II: ***Pervasiveness of market failures***

40. The purpose of this part of the discussion is to consider one aspect of the validity of the preceding argument, namely:

- How significant are market failures in developing countries? Are they of negligible importance, significant but small, or quite large? Are they more significant in developing countries than in developed countries? In so far as they are non-negligible, do they tend to be concentrated in certain industrial sectors or are they fairly widespread? (How much is really known about their size and distribution?)

Topic III: ***Extent of intervention***

41. Let us assume that the government of a developing country has committed itself to maintaining an open economy with macroeconomic stability and no major policy-induced distortions. The purpose of this part of the debate is to exchange ideas on whether these conditions are sufficient to permit the market mechanism to stimulate adequate investment in skill formation and the adoption of new technologies or whether additional, more specific policy measures are needed.

42. One way of looking at the issue depends on the existence, size and dispersion of market imperfections -- particularly externalities -- discussed under Topic II. The free trade view downplays imperfections and calls for reliance on price signals and international trade for allocating resources to technological change. The interventionist position rests on the premise of market imperfections sufficiently large to permit the benefits from their removal to offset the social costs of the intervention. In so far as externalities are both modest in size and widespread, the prescription would seem to be for low, uniform rates of subsidy to technology accumulation and low, uniform import protection until comparative advantage is reached. The case for more overt forms of selective intervention, including temporary tariffs, quotas and subsidies, depends on the existence of indivisibilities and large externalities concentrated in a few firms or products. Are the preceding remarks an accurate assessment of the issue of whether and how much to intervene or should other factors (such as level of development) also be taken into consideration?

Topic IV: ***Forms of intervention***

43. The subject of this part of the debate concerns the rationale for different kinds of government intervention. Without attempting to be exhaustive, these may range from (i) catalytic support for co-ordination among the various stakeholders in the industrialization processes, such as MITI's role in Japan, in bringing together government and business officials informally; (ii) subsidies (subsidized investment, tax relief, support for specialized education and training); (iii) establishment of standards, quality testing and certification; (iv) government procurement (responsible, some claim, for the establishment of the U.S. aerospace and electronics industries); (v) technology transfer and foreign investment measures (guidance in negotiations with foreign firms, screening of, and performance requirements on, foreign direct investment and technology transfer); and (vi) establishment of state enterprises of fixed duration (in strategic industries where private investment is not forthcoming). The experts are invited to consider the pros and cons of the different types of measures and the criteria (such as directness, temporariness and budgetary or administrative requirements) that should govern their use. An interesting question is whether policy discussions based on welfare analysis of corrective taxes and subsidies have neglected the co-ordinating role of the government. A further question relates to intellectual property rights

protection. It has been argued that the degree of such protection should not be uniform but consonant with the stage of development. The experts may also wish to consider this technology policy issue.

Topic V: ***Technological protectionism in the North***

44. It was implied at the beginning of this note (Topic I) that in the real world there are three groups of countries. The first group is the innovator, the second group imitates, which are described by the technology-gap models, and the third group is attempting to become an imitator, to which these models do not apply. Current trends indicate that, as the number of countries moving from the third to the second group increases, we can expect increasingly protectionist measures from the innovators. What strategy should the second and third group of countries adopt? Is regional integration the only alternative for these countries to increase their leverage in countering protectionist threats from the North, while retaining an outward-oriented strategy of industrialization?

C. Conclusion

45. In summing up the debate, an attempt will be made to take stock of how much the gulf between free traders and interventionists may have narrowed as a result of the explicit introduction of technology into international trade theory. Suggestions on future directions of UNCTAD's research on technology policy issues will be welcome.

COMMENTS BY THE EXPERTS

Annex III

By

Paul A. David

1. Introduction and motivation

46. More than 15 years ago, Harry Johnson (1975), in an article entitled "Technical change and comparative advantage: an advanced country's viewpoint", called attention to the importance of technological innovation as the "chronic disturber of existing patterns of comparative advantage". Although it has taken some time, the economics profession can now claim to have at last absorbed the point. One obvious manifestation of this is to be seen in the large and rapidly growing literature associated with the industrial organization approach to international trade theory, and with technology-gap models of trade in particular. (See the excellent survey by Goglio 1991; also summarized in annex I above.)

47. This recent trend in economic analysis focuses upon the relationship between technology, trade, and long-run growth, rather than on the classical questions concerning the size and distribution of short-term (static efficiency) gains that could be achieved by moving to an open-economy resource allocation regime. International differences in production techniques and in technologically based product characteristics now occupies the centre of the field in explanations of the structure of comparative advantage and the pattern of trade; factor endowment differences (along with the Heckscher-Ohlin models in which they figured so prominently) have been pushed to the sidelines.

48. A related distinctive feature of the new analytical outlook is the treatment of the sources of differences in the techniques employed in various places as endogenous, rather than exogenous, to the dynamic process under examination. Economies of scale and externalities of locational agglomeration are realized through the expansion of production and the geographical redistribution of mobile resources. Technological progress, as distinguished from the realization of static scale economies, is depicted as resting on the accumulation of knowledge obtained by investments in R and D, and by the acquisition of production experience (dynamic, irreversible scale economies characterized as "learning").

49. In the genre of technology-gap models of trade surveyed by Goglio 1991 *op.cit.*, the differential pace of technological progress is depicted as the force creating international divergences in comparative advantage and asymmetries in national patterns of foreign trade. It is supposed that additions to the stock of knowledge generated in one country will have positive externalities for firms located there, but that they do not diffuse rapidly across national borders, even though there will eventually be international "spillovers" and imitation (based on reverse engineering) by producers in other countries. General equilibrium models of North-South technological development and trade, such as those constructed recently by Grossman and Helpman (1989 and 1990), suggest that the transfer (imitation) of technological innovations generated in the North, and their application to the production of tradeables in the initially lower-wage South, must work to increase the specialization of the two regions. Northern commodity production is forced to contract by the Southern imitators, and (given the assumptions of full employment and labour malleability) the displaced workers are absorbed into the R and D activities of the North, thereby increasing the global rate of technological progress.

50. What should we take from this when considering the role of technology and the scope for technology policy measures in the developing countries? How reasonable is it to identify the latter with the stylized, technologically laggard "South" of these models? How informative is their characterization of the processes of technological innovation and diffusion ("transfer"), and of the conditions affecting them? In responding to these challenging questions I want simply to sound

three notes of caution.

51. The first point involves the connection between technical change and changes in resource endowments, and is occasioned by the potentially serious disjuncture between the empirical observations that the new trade theory has sought to address, and the realities of the developing country economies, especially in regard to the relationship between technological change and natural resource endowments. The second concerns the overly-simplified conceptualization of the nature of technological knowledge in these models, and its implications for the treatment of "imitation" and technology transfers. Following on from that, my third note of caution touches briefly on the potentially misleading implications that could be drawn from this literature in regard to the respective interests of the developing countries and the advanced countries in institutions for the protection of intellectual property rights.

2. Technology and resource endowments

52. The shifts in theoretical orientation that have been cursorily reviewed here should be seen as a thoroughly commendable effort to accommodate better the empirical evidence that has been assembled for the industrially advanced economies of the post-World War II era (see, e.g., Dosi, Pavitt and Soete (1990)). Much of the trade of these countries is found to take place with countries that have similar conventional factor endowments; within specified industrial sectors, there appears to be so substantial a degree of "cross-hauling" as to be incompatible with traditional Heckscher-Ohlin trade models and explicable only in terms of the existence of product differentiation and monopolistic competition in international commodity markets. Indicators of R and D performance, and innovation output measures such as patenting rates, and the relative importance of new product sales in sectoral revenues, reveal marked inter-country differences and a high and persisting degree of concentration of innovative activity in a relatively small number of the already economically advanced countries. In manufacturing as a whole, and in individual branches of industry, international differences in intensity of innovation activities are positively correlated with shares of world export markets. Changes in nations' trade performance and net exports, similarly, are associated with changes in innovation activity measures and relative labour productivity standings.

53. It would be salutary -- especially for those concerned with the implications of these new theoretical perspectives for the formulation of technology and trade policies in the developing countries -- to start by asking whether the developing countries' sectoral structures, patterns of trade, and innovation activity levels (normalized for the size of the economy) resemble the picture that has been constructed for the industrially advanced regions, and which therefore is reflected in idealized form by the "new" trade theory. There are grounds for doubt and for believing that factor endowment -- and natural resource endowments -- figure more importantly in determining the patterns of comparative advantage among the former countries. That in itself should not be presumed necessarily inimical to rapid industrial development. Indeed, during the era of the United States' rise to industrial pre-eminence and the country's emergence as a major manufacturing exporter, which is to say roughly speaking from 1880 to 1920, the natural resource intensity of American manufactured exports actually was rising (see Wright, 1990).

54. Of course, in referring to the historical experience of the United States in this regard, I do not mean to suggest that present day developing countries can automatically follow suit, any more than modern day relationships observed in the advanced industrial economies between innovation activities and the dynamics of comparative advantage are immediately relevant for them. Yet, it is important to insist that natural resource endowments are not really exogenously determined. The world's economically exploitable stock of known resources -- its reserves of mineral deposits, for example -- has grown enormously, and changed in geographical distribution as a consequence of investments in exploration and exploration techniques, improvements in methods of extraction and refinement, alterations in transportation costs, and so forth.

55. Once again, the historical perspective may be informative here. Closer examination of the late 19th century experience of the United States reveals that the country was exploiting its natural resource potential far more intensively than many other regions of the world (see David and Wright (1991), section 2). The condition of "minerals abundance", that underlay the rising natural

resource intensity of American manufactured exports, developed endogenously from the 1840s onwards. It was, of course, an outcome of the mobilization of private resources for exploration and exploitation of the continent's mineral deposits. But that market-governed process was directed in important ways by the accumulation and application of the scientific knowledge obtained from governmentally-funded and organized research in geology and metallurgy; it was shaped, too, by the development of new methods for the extraction and refining of metals, coal and petroleum, and the dissemination of information about these techniques through the curricula of specialized engineering schools (see, David and Wright (1991), sections 3-4, for all these points).

56. So, although the "new trade theory" has paid it scant notice, the possibility should not be ignored that one important way for the comparative advantage of contemporary developing countries to be altered by technical change is through the latter's impact upon the effective endowments of depletable and non-depletable natural resources. Of course, this might be seen as just a special instance of the more general point -- familiar enough in the old growth theory, if largely overlooked in the more recent literature -- that "non-neutrality" in factor-augmenting technical change may alter the relative rates of remuneration of factors that are elastically supplied, and in that way may transform a country's comparative advantage (see, e.g., Abramovitz and David (1973)).

3. Technological knowledge and problems of "learning to borrow"

57. The basic conceptualization of technological knowledge in the technology-gap literature is that it is codified information which, because it is unambiguous and cheaply transmitted, is difficult to keep from "leaking out" for more than a brief interval of time. Competitors, it is supposed, soon will learn enough of a new technique to borrow it. A related variant view is that the essential technological knowledge is embodied in the very design of the product, and hence, with some effort and expense, it can be retrieved by "reverse-engineering". There is certainly enough that is true in the foregoing characterizations, particularly when applied to the situation of innovating firms in the technologically and industrially advanced countries. But, because it conveys only a part of the truth, the picture that emerges tends to understate the very considerable problems that may attend the transfer of complex, modern technologies to developing countries.

58. Yes, there is codified technological knowledge, but there is also uncodified tacit knowledge which is complementary to it. Without the latter, production processes will not deliver output of the expected quality at the anticipated rate. Some of this tacit knowledge consists of the details and material specifications that have been omitted from the "blueprints" intentionally, or simply because they are so "standard" in the country where the design originated that specifying them is regarded as unnecessary. Others may reside in the expertise of production engineers, or of the workers. The more complex the process or the product design, the greater the dimensionality of the tacit knowledge problem. For example, as Steinmueller (1989) has pointed out, the knowledge involved in effective production of advanced information technology products entails far more than the transfer of a set of blueprints. Differences in the availability of individual components, subtle effects resulting from seemingly minor adaptations in design to accommodate local least-cost methods of manufacture, the necessity of achieving inter-operability with other information technology systems that are not "standard", all may frustrate attempts to implement a patented process or product design. This is especially so if that attempt is made in a foreign industrial setting, without access to the tacit knowledge of agents who have experience in getting the technology to work in its original setting.

59. The greater the technological distance between firms, in terms of the degree of overlap or disjointedness in the domains of their production experiences, the more serious is the problem posed by tacit knowledge. Tacitness itself implies that the agents will not have a conscious, focused perception of what it is that they know which is critical for successful operations. The smaller the set of analogous experiences, the more difficult it is likely to be for one firm to elicit from the other the list of subjects about which it should be seeking further information. Of course, common training of skilled personnel and easy mobility of such personnel among firms will help greatly in overcoming these problems and, hence, increase the likelihood of successful implementation of codified technologies "transferred" via licensing of patents, reverse engineering, or

imitative R and D programmes.

60. The assumption that technology will automatically "leak out" to developing countries in much the same way -- albeit with a little longer lag -- that it becomes diffused among competing firms in the technologically advanced region of its origin therefore seems unwarranted. A corollary of this, however, is that the successful transplanting of advanced technologies may have important externalities in building up stocks of tacit knowledge in the receiving country, which will make it cheaper and less risky to transfer other analogous or technically-related innovations. The development of technological competencies in a particular field, especially one such as information technology that has pervasive applications across a range of industries and sectors, will also make it more feasible for potential borrowers to monitor the advance of the knowledge-frontier and identify the most competent innovating firms from whom they might seek to acquire access to the newest relevant techniques. The acquisition of competencies of these kinds might well be termed "learning to borrow".

61. The self-reinforcing, positive feedback mechanisms to which the foregoing observations have pointed imply that there may be marked divergences in the rate of imitation or "technology-absorbing capacity" across industries, and even across broad sectors of developing economies. These, however, have remained largely unrecognized in the technology-gap literature, which has focused attention instead upon positive feedback mechanisms that operate to generate divergences in rates of innovation in the industrially advanced countries. Exploring the properties of open-economy models that incorporated positive feedbacks affecting the rate of technology borrowing or "imitation" alone, or which combined them with positive feedbacks in the rate of innovation, undoubtedly would uncover much richer dynamics -- and suggest policy implications rather different from the ones that have emerged to date.

4. Intellectual property protection, innovation and diffusion

62. Many of the familiar trade-gap models, and notably the general equilibrium North-South product cycle model of Grossman and Helpman (1990), serve to reinforce the view that, under conditions of free trade, the economic interests of the developing countries (i.e. "the South") are identified with conditions in which it is easy and inexpensive to "borrow" or copy new technologies: whereas the interests of "the North" are seen in these models as being bound up almost exclusively with the generation of innovations.

63. This reinforces the long-standing notion that there is an unavoidable conflict of interest between the technology-borrowing developing countries and the technology-generating advanced countries over issues of protection for intellectual property. In the 1960s and early 1970s, UNCTAD articulated the charges of many developing countries that the international intellectual property system was biased against them, in that it gave monopoly rights to foreign holders of patents and copyrights at the expense of consumers in their countries (see, e.g., Mody (1990); UNCTAD (1991)). The explicit justification offered for not subscribing to international patent and copyright conventions was essentially a distributional or equity argument: poor countries, at their "stage of development", ought not be asked to pay for knowledge that would ultimately be part of the universal heritage of mankind.

64. A rather different rationale that might have been given for regimes of weak intellectual property protection in the developing countries' markets is that, in most cases, those were not, in any case, the ones for which the patentors and copyright-holders had targeted their creations. So that while it might be debated as a matter of equity that, being beneficiaries they should pay, or that being poor they should not be asked to pay, the important point remained that it would not much matter from an efficiency standpoint; the world's supply of such innovations would not be much diminished, if at all, by these countries' adoption of a "free-riding" policy.

65. In the event, India, Brazil and Argentina, among other countries, passed laws restricting the scope of intellectual property protection. Although the international system of protection was somewhat strengthened during the 1970s by the expansion in the number of signatories to the Paris Convention for patents, and the Berne Conventions for copyright protection, during the 1980s the United States, supported by other industrially advanced countries, began pressing for a much

greater strengthening of the machinery to enforce compliance on the part of the signatories, and to induce the "hold-outs" to join. Increasingly, trade sanctions have been invoked by the United States in pursuit of that goal.

66. This is an arena of great contention, into which I do not want to enter, save to make a simple observation that there is another face to the North-South conflict over intellectual property protection which is too often overlooked. The difficulties that the complementary role of tacit knowledge creates in successfully transferring codified technological information from advanced to developing countries suggests that involving firms from the former countries, via co-operative ventures and technology support and training contracts, will be in the interests of firms in the latter countries (and one should consider, too, that there will be the positive externalities in the form of "learning to borrow", as has already been noted.) While information asymmetries and monitoring difficulties make it virtually impossible to write efficient contracts specifying the transfer of tacit knowledge, it is possible to design contracts for the successful implementation of technologies by bundling the provision of assistance together with the licensing of the use of codified information such as patents and copyrights (see Arora 1991: Chapter 5). But, if protection for such property is weak in the borrowing country, the originating firm is unlikely to enter such contracts. The implication of this is clear: the would-be borrowers of technology have a interest in a regime of stronger protection for intellectual property, either through statutory measures, or judicial enforcement of trade secrecy rights.

67. The foregoing conclusion is distinct from, but not at odds with, Chin and Grossman's 1990 contention that (because the prospect of licensing patents to the "South" would stimulate a faster rate of innovation in the "North") both technology-generating and technology-borrowing regions stand to gain from an international regime providing strong protection of intellectual property. While it is a useful step towards revision of the simplistic "ineluctable conflict" view of North-South divisions over intellectual property rights protection, Chin and Grossman (1990) have simply re-emphasized the potential externalities of lending encouragement to innovation in the North. Instead, by focusing on the conditions for successful transfer of codified and tacit information regarding innovations that have already been made in the North, the foregoing analysis suggests that the South would gain, even when there was no incremental innovation-inducement effect of extending intellectual property protection into its own markets.

68. To complete the proposed reversal of conventional thinking on this matter, it may also be pointed out that strong protection for intellectual property, especially the upholding of broad patent claims, and judicial use of injunctions and criminal prosecutions in trade secrecy cases, can have seriously perverse effects upon economic growth and welfare in the North because such measures tend to stifle innovation. The protection of one firm's property places constraints on the ability of other firms to extend profitably, improve and integrate that element of technology into larger, more productive systems. Technological progress is a cumulative and synergistic process, carried on by a multiplicity of actors with heterogeneous competencies. It is true that competition under conditions of free entry may result in an untidy and duplicative research process, marked by wasteful patent races among rival firms. But, on the other hand, the rapid disclosure of, and inexpensive access to, existing advances in knowledge -- as the experience of the West with the institutions of open science has amply shown -- is a recipe for rapidly expanding the stock of verified knowledge, especially if public subsidies are made available to provide incentives for those engaging in the risky business of research. Broad patent protection tends to have the opposite result, by monopolizing the development and elaboration of breakthrough innovations in the hands of the originating firm, which may have neither the incentive nor the technical competence to pursue such work most expeditiously.

69. This last point is an important consideration that has received notice recently from economists concerned with the issue of the optimal scope or breadth of patent protection (see, e.g., Klemperer (1990); Merges and Nelson (1990); Scotchmer (1991)). Unfortunately, it is persistently obscured from view in the technology-gap theory of trade literature by the fashionable analytical simplification of treating the innovating North as if it consisted of only one firm engaged in R and D (see, e.g., Chin and Grossman (1990)).

70. Rather than emphasizing the familiar view that instituting strong enforcement for patents, copyrights and trade secrets involves accepting the trade-off of static efficiency losses (due to monopoly restrictions on technology utilization) for faster productivity growth via technological innovation, we would do better to couple it with the obverse proposition. Tolerating weaker and

narrower protection of intellectual property rights involves accepting the trade-off of slower and less widespread diffusion of technological innovation to developing countries, in exchange for a more rapid pace of knowledge accumulation. This would be true, at least in those sectors of the advanced economies where R and D project costs are modest enough to permit recoupment by firms that have only a brief period of technical advantage over their direct competitors.

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By

Giovanni Dosi

1. Increasing returns - static and dynamic efficiency

71. The notes which follow are some scattered and rather unorganized comments triggered by the discussion within the group.

72. With a few extremist exceptions, there is relatively widespread agreement that technical change most often involves various forms of externalities and dynamic increasing returns, involving possible market failures and generally multiple equilibria. This, in turn, implies what has been termed as the possibility of dilemmas between "static" efficiency, on the one hand, and "dynamic" efficiency or "Schumpeterian" efficiency, on the other. (The argument has been presented in detail in G. Dosi, K. Pavitt and L. Soete, *The Economics of Technical Change and International Trade*.)

73. One dilemma stems from the fact that the pattern of current economic signals and the pattern of returns to individual agents might be a poor driving force for, and a poor predictor of, long-term innovative opportunity. Putting it in a different way, it might well be that, given the current pattern of economic signals which are determined by the current pattern of technological leads and lags, individual economic agents might find it profitable to continue to produce, for example, potatoes, in which they have comparative advantage, even though they may well know that potato-growing has a lower innovative potential than an activity characterized by high dynamic increasing returns. Similarly, in this example, they might find it profitable to choose potatoes rather than a generic technology such as electronics, which can serve as an input to many other activities. Still, each individual agent, reacting to current signals, finds it rational to grow potatoes, given the capabilities that he embodies and the difficulty of internalizing the externalities associated with innovation. (Note that this argument applies irrespectively of whether agents have 'rational technological expectations', provided that innovations are not perfectly appropriable).

74. Secondly, even more controversially, when the general equilibrium framework and the idea of generalized substitution in consumption are abandoned, it can be easily argued that the fact that some productive activities are more income-elastic than others does matter for growth. This means that one could be very good at producing, even in an innovative way, goods that no-one wants to buy, in contrast to acquiring progressively the capacity to produce highly income-elastic goods. One of the ingredients of the Kaldorian explanation of backwardness is precisely the vicious circle associated with agricultural products that have low-income elasticities (possibly below one), which imposes increasingly tight balance-of-payments constraints and induces levels of output lower than what specialization in income-elastic activities would allow.

75. In fact, most 'late-comers', from Germany and France in the last century, to Japan and the Republic of Korea in this one, have followed, explicitly or implicitly, various kinds of policies to address these potential dilemmas in the process of their development. They have explicitly distorted market signals in order to implement policies intended to make it more advantageous for private actors to undertake production and innovation in areas that, in one way or another, were considered to be strategic and provided growth opportunities -- heavy industry in Germany in the last century, electronics, mechanical engineering and electromechanical engineering in Japan in the present one.

2. *Technological and development policies*

76. There are two major domains upon which policies operate. The first covers general technology policy and, in this domain, there is, I hope, near unanimity. It covers education, infrastructure or, at a slightly higher level of development, the capability of the national scientific and technological system to provide knowledge, freely available information, a highly educated labour force and associated with that, on the hardware side, infrastructure such as telecommunications, electric power systems and roads.

77. The second domain which policies can affect is much more controversial and covers the capabilities of the agents themselves in terms of the technology that they embody; their internal organization; industrial structures; patterns of entry and exit. With very few exceptions and also some excesses, as in the case of MITI, part of the development process in many countries has implied messing with the industrial structure and actually strengthening national oligopolies. In the more successful of these countries, however, the encouragement of concentration and oligopoly has gone hand-in-hand with other policies aimed at increasing competition and preventing the simple pursuit of monopolistic rents in a protected home market (as has most often happened with 'import substitution policies' in Latin American countries).

78. In this domain, policy also operates by distorting the signals given to the agents. If, for example, as in the case of the development of the semiconductor industry in Japan, the introduction of prohibitive protection is accompanied by the announcement that such protection is temporary, and, moreover, by the encouragement of fierce competition among domestic producers this, of course, will lead to changing the signals that individual agents would naturally face. However, it seems to me, successful technology and development policies make an instrumental use of purposeful 'distortions' of market signals, and together, try to make policy objectives also incentive-compatible. (In this respect, I would be inclined to suggest a rough pragmatic rule: the more one intervenes on industrial structures, trade patterns, criteria for resource allocation, the more one should also provide for competitive mechanisms and selection on the markets for both products and finance.)

79. In fact, taking the historical examples of industrialization as a guide, one should not discuss whether intervention should occur in the technological domains, but how much and what form it should take. In this respect, there are significant differences also in the contemporary experience of developed countries. For example, there is a major difference between Europe and the United States, on the one hand, and Japan, on the other. If anything, Japan spends less to support private research and private technology but has got a much wider menu of policy instruments. To put it in another rather extreme way, Japan has got an instrumentalist view of markets, in the same way as the old French and German traditions, which relied on markets only so long as they served certain objectives (e.g., 'industrialization', 'power', expansion on the international markets, domestic growth). According to this view, markets are often accepted to be the best way of organizing productive activities because one does not know of a better way. But there are no illusions about some general Pareto optimality-of-market mechanisms. Price signals are simply instruments to mobilize resources, to mobilize people, to make them innovate and then to check their performance through some kind of a selection mechanism. By contrast, the Americans and many contemporary European countries are subject to a much more sacred notion of markets. Hence, somewhat curiously, industrial and technology policies are more easily implemented whenever they are justified on the grounds of some extra-economic objective. For example, Americans have not had explicit industry policies and the major substitute for an industrial policy has historically been military and space policy. Alternatively, policies are sometimes justified on the grounds of some (quite narrow) notion of 'market failure' on the market for 'information' (under the assumption that technology can be simply equated to the latter). So, among the European countries, a few have had R and D relying mainly on transfer and subsidies to private companies, but with a lot of 'liberal' inhibitions to intervene deeper into industrial structures, to set technological and industrial targets, etc. In my view, this poverty of policy instruments has been also one of the reasons for the limited European success with technology policies (at least as compared to Japan). The typical justification for the policy philosophy: "Why should governments know better than businessmen what to do?" in fact loses a lot of its theoretical underpinnings in a world characterized by various sorts of dynamic increasing returns, multiple equilibria, tacit and 'local' learning and possibility of lock-in within sub-optimal technological trajectories.

80. In sum, it would appear that there is no guarantee that the process of learning induced by decentralized efforts has got any kind of optimal characteristics. Even within quite orthodox theoretical frameworks, it can easily be shown that, with dynamic increasing returns, etc., market mechanisms (and, relatedly, prices) lose the efficiency properties of decentralized allocation which can be shown to hold with convex technologies. Indeed, in my view, the power of the market does not reside in the fact that it allocates resources well -- in fact it might do so badly -- but in its ability to serve as an extremely powerful selection device, and to provide, as Williamson would put it, high-powered incentives to learning and discovery, even though lacking any allocative optimality at any and every point in time. In fact, so far, the greatest and perhaps most convincing argument against public intervention is not economic but politico-administrative and pragmatic; that is, bureaucracies may well fail to trigger development on an normatively "better" trajectory and, in addition, curb market incentives and selection. To put it vividly, as an Italian (but certainly the view ought to be shared by many citizens from developing countries), with a bureaucracy like our's, anything is better !

3. Finance and development

81. Financial policies also have a bearing on technological development and thus need to be discussed in relation to technology policy. It is obvious that, before getting an activity going, there is a need for start-up investment. In fact, one of the biggest bottlenecks to technological development is probably the lack of devices that centralize capital accumulation. In most developed countries such accumulation has occurred either through a bank-base system or a market-based system in which industrial expansion is financed via issuing and trading ownership titles and bonds. Of course, examples of the former are the German Universal Bank or the Japanese *zaibatzu*. In my view, this system has been the normal way of development, and the Anglo-Saxon case, with dependence purely on a stock-exchange and markets for ownership, can be considered a peculiar historical exception. The task of financing industrial accumulation has been performed very well, or quite well, in most of the other now-industrialized countries, precisely by a group of banks which had possibly also the advantage of accumulating special competences that were not, and are not, common knowledge, among anonymous investors. This also allowed banks -- if one accepts the Hirschman dichotomy between "voice" and "exit" -- to exercise "voice" rather than "exit" mechanisms of control upon performance. Putting it in a loose way, the typical pattern of bank-industry relationship in such a set-up involves the banker not saying much if companies are doing well, and stepping in trying to redress the problems of the company if it is doing badly, rather than delivering an "exit" message (i.e. selling the shares). With scarce managerial talents, requirements of long-planning horizons, postponed profitabilities and, possibly, high potential synergies between different activities, this is probably a more development-conducive financial structure.

82. A second point concerning both the financial system and the public administration relates to their "business-friendliness". Both should be "business-friendly" and "businessmen-unfriendly". Quite often, however, it is the opposite; both financial institutions and bureaucracies are risk-averse, conservative in their choice, wrapped-up in red tape, but very friendly to a small oligarchy. Most successful countries, however, have had an administration which, for reasons of ideology and or internal culture, has placed itself above particular interests. Motivated by the desire for national power, or other extra-economic ("higher") motives, these administrations have been able to justify the unfriendliness to individual businessmen. Successful administrations must be able not to be "nice" to individual businessmen while pursuing some collectively shared objectives. With that, I have in mind the administrations of Japan, Germany and the Republic of Korea (and, historically, France). As opposite examples of public administrations that immediately become part of a lobbying system and of financial institutions which strengthen rent-seeking positions of privilege, see the cases of most Latin American countries. Let me be quite blunt on this point: it seems to me that with rent-seeking oligarchies, technology and development policies can hardly be successful, irrespective of the degrees of *laissez-faire* in other domains (e.g., trade policies or privatization).

4. State-owned companies

83. A similar argument applies to State-owned entreprises. A lot of emphasis has been recently put on the virtues of privatization. In fact, let me introduce two major caveats. First, in my view, in a few activities the lumpiness of start-up investments might be such that they can only be undertaken by big industrial/financial groups or by the State. There are cases where publicly-owned companies can do things that no individual investor would be ready to undertake and by doing so enhance technological learning and produce powerful externalities. For example, in Italy, a significant part of the industrialization in the 1950s and 1960s and the resulting development in basic industries, such as steel and energy power plants was due to publicly owned companies. Moreover, Italy would not have achieved a significant production of microelectronic devices had if not been for the activity of the State. (Interestingly enough, the state activity in microelectronics was not originally motivated by any "strategic" consideration, but to protect jobs!) However, again, the crucial point is how to shield public companies from political interference, not the ownership structure as such. And this leads to the second caveat: what seems to matter most is not the legal status of ownership but the selection processes in which firms are embedded with respect to product markets and financial resources. Or, to put it the other way round, does anyone seriously believe that by transforming, in the ex-Soviet Union or in Latin Amnerica, state monopolies into private ones, performance will dramatically improve?

By

Elhanan Helpman

A. Technology-gap trade models

1. General remarks

84. With regard to Mr. Goglio's paper, I should like to point out that the new growth theory has not been designed to deal with developing countries. It has been designed to deal mostly with developed countries. The new trade and growth theory has followed this trend and it is not a coincidence that in Grossman and Helpmann (1990), there are only two chapters that deal with North-South trade. I think that we are only at the beginning of the process of dealing with the issue of growth and trade in developing countries. Essentially, the new literature provides some insights, which could be useful for the developing countries, but it does not provide precise answers. In the paper, Mr. Goglio makes the distinction between discrete and continuum models. This distinction might be useful as a first approximation, but overall I do not think that it is very useful. According to the definition of these two types of models, they can be combined, and in fact, they have been combined. The fact that there is some comparative advantage ranking in manufacturing, on the one hand, and comparative advantage ranking in R and D, on the other hand, these two can be combined to generate a coherent and integrated theory. Some work along these lines already exists. New products can embody different technologies as compared to old products and they might be cheaper to produce in some countries because of their resource composition. This does not mean that the country which has the comparative advantage in manufacturing is necessarily the one that also has the comparative advantage in the development of the product. In addition, there have been studies that look at the process of learning in manufacturing as opposed to the process of learning in R and D, and the view seems to be that the learning in manufacturing gets exhausted after a while and for this reason production would migrate from one product to another, usually to a newer product.

85. Most of the models of product cycles in the technology gap theory that have been reviewed are single-factor models. Obviously, this is only a simplification and there is much to be gained by expanding the range of inputs that are used both in manufacturing and in R and D. This extension, for example, would be critical to understanding the process of transfer of technology via multinationals, on which there is relatively little work, using the new trade theory. In discussing policy issues, a distinction for developing countries in terms of technological capacity would be helpful. Most of the models that have been reviewed deal with imitation, but as has been pointed out, this does not describe well the majority of developing countries. An important technological capability is the ability to absorb technologies. This might be at least as important as the ability to reverse-engineer. Thus, there is a range of technological capabilities which are critical for development but not necessarily of an imitative nature. Again, technology transfer via multinationals can be quite important. There are some empirical studies which look at the relationship between the extent of multinationality and productivity both across sectors and across countries. There definitely exists a degree of correlation between the two and there are mechanisms that generate these correlations. Thus, the usefulness of multinationals and the policy towards multinationals are both heavily influenced by the very reasons for which companies become multinational. If a company jumps tariff walls or tries to exploit tax concessions, the policies needed would be quite different from those if the company were interested in exploiting cheaper production. This is one of the main reasons why the literature has not addressed this question in greater detail, i.e. because one would need to deal with a great many issues and model every aspect separately.

2. *Welfare implications*

86. It is quite common today, in various discussions, to draw strong welfare conclusions from this new growth and trade literature, which might not be justified. There have been very few robust welfare effects analyses. The fact that there is a policy of one sort or another which generates faster growth and faster innovation does not, by itself, imply that there is a welfare gain. Thus, the association between faster growth and higher welfare gains is not a simple one. One should disassociate welfare implications from the effects of growth and, in each instance, a careful analysis is required to identify what the welfare effects are of a slower or faster rate of growth. For example, it is the case that, even in the simplest types of economy, the equilibrium rate of growth can be too fast or too slow, despite the fact that there exist externalities that can bias the rate of growth downwards. However, there also exist other effects, which are of the Schumpeterian nature, that can bias it upwards. Thus, there are cases where the rate of growth can be too high or too low. There are three elements at which one can look in general. Firstly, if there are externalities of the various types associated with technical change, there will be consumer surplus effects that bias growth downwards, because the externalities are not taken into account by the innovator. Secondly, there will be some profit destruction effect, or what Schumpeter called "creative destruction", because if one invents a new product, one usually reduces the profitability of other activities in the economy. This biases growth upwards. Thirdly, there exists also some market power which comes with the innovation, and this market power is needed in order to generate the incentive to innovate. It biases resource allocation in a particular direction. All these elements have to be added up and in the end yield the result that growth can be too fast or too slow. So, even from this narrow perspective, one cannot say that faster growth is necessarily good. This is so because growth does not come at a zero price. Basically, growth has a price which is equal to the resources that have to be withdrawn from other activities in order to generate growth. Therefore, since growth is not exogenous, one has to take into account these elements.

87. There has been almost no robust welfare effects analysis. However, on the basis of my calculations, I can point to some welfare results. In general, if one thinks about the existing technology-gap models, and they are much too narrow for the purposes at hand, the following is true. Innovations *per se* are useful because one either gets more variety or an improvement in the production process. Imitation *per se* is also good because it shifts production from a high-cost country to a low-cost country. Thus, other things being equal, if there is a difference in costs, it is better to produce in the low-cost country. However, there are costs associated with both innovation and imitation. I do not have to dwell on the reasons for the costs associated with innovation. I believe that there are also major costs associated with imitation. For developing countries, there are no precise estimates of the costs of imitation, but there are estimates for the costs of imitation in developed countries. Thus, Mansfield estimates that the imitation costs are of the order of 60 per cent of the cost of innovation. Some studies in the World Bank, which did look at the developing countries, found that these countries also invest substantial resources into reverse-engineering. Such costs have to be taken into account. Even if imitation and innovation are good, there is a price tag attached to them and that has to be accounted for.

88. Another point is that, whatever change occurs in the system, there is a change in the terms of trade in the narrow sense. In fact, I would like to restrict my discussion to what is called the factoral terms of trade because, if one wants to use commodity terms of trade, one has to take into account the change in the composition of goods. Just to demonstrate why one has to be very careful, assume that the rate of imitation and innovation are exogenous and that they cost nothing. In this case, there are no resource costs of the type mentioned. In Mr. Goglio's paper, there is a review of results that relates to the shift in the size of the labour force of the two countries. What happens in these instances is that labour becomes more productive in one country. By assumption, neither the rate of imitation nor innovation changes, so one is left with factoral terms of trade. The welfare implications are simple; whichever country improves its factoral terms of trade gains, and whatever country worsens its factoral terms of trade loses. In this case, in per capita terms, there is always a loser and a winner. Let us consider the case where the rate of imitation increases exogenously. This leads to a shift in the output of manufacturing from the North to the South which is good, because we move production from a high-cost country to a low-cost country, which is efficient. What are the implications for the South? In the South, the factoral terms of trade improve, so the South comes out as clearly gaining, because there is more production efficiency in the world and it has better factoral terms of trade. The North gains because some of the goods

are produced in the cheaper South, but its factoral terms of trade deteriorate. Hence, one does not know whether the North gains or loses. When the rate of innovation goes up, everybody benefits, but the South's factoral terms of trade deteriorate. Again, the net effect needs to be calculated. Thus, it clearly emerges that one needs to be careful when drawing conclusions about welfare effects.

B. Policy issues

1. The use of trade policies

89. The technology-gap models suggest that one can design government policies which will be helpful in one way or another. It is important to stress that these are typically not trade policies. Whatever policies might be desirable, they are of a different dimension and have little to do with trade policies. One may think that policy intervention brings about large welfare gains, but one should remember that policy mistakes also have large welfare effects. To design good policies, one requires very fine information which is very scant.

90. In the area of technology, if there are externalities, then the remedy for these externalities is in technology policy and not in trade policy. For example, if there is not enough R and D, the right measure is to promote R and D and not to protect the industry, because the protection of the industry has secondary effects which can be as detrimental as the improvement that might come out of the protection. If the failure is in the credit market, then the government should correct this failure through direct policies, for example, by subsidizing credit and not by protecting the industry. If there is a failure of the type related to the insufficient amount of skilled labour in the economy which might be linked to problems in the credit markets, again, the use of trade policy will be inefficient.

91. The problem of lack of skilled labour is also important for the developed market economies. If one thinks that the evolution of the industrial sector, and even services, will go along the lines where there is a lot of technological progress, there exist various skills that one can provide and that would be helpful in a variety of occupations. In this whole area of skill creation, what one needs is quite a bit of flexibility and this definitely applies to the less developed countries. They have to adopt so much new technology and so many new products for the future. This would take time and governments should provide enough flexibility in the education system. But the main point is that, in the area of trade policy, if there is anything relatively clear, it is that one should opt for an open-trading system. There is a piece of evidence worth mentioning which is quite interesting and comes from a study conducted by a student in Harvard University. He has been doing cross-country regressions of growth on a variety of variables, including investment equipment, or investment equipment imports. Looking at the cost of investment equipment in various countries, he found that where it is low, growth rates are higher. Therefore, if governments make it difficult to invest because they raise the cost of investment, this would be detrimental to growth. Everyone would agree on this. Furthermore, this student looked at the imports of investment equipment relative to investment and relative to GNP and he found an extremely strong effect of imports of investment equipment. Moreover, if he puts in the equation some measures of openness, such as percentage of GDP that is traded, then the investment varies with imports and not the other way round. Although one might explain it in a variety of ways, it is obvious that countries, especially developing countries, need to rely on major imports of capital goods from the developed world. Pursuing a protectionist policy does not seem to be the right strategy for promoting growth and this is particularly true in cases where there is no direct resource cost involved. So, countries should take advantage of imports.

92. There is one case which has been analysed and that is the issue of identifying international carriers of spillovers. It is a major issue. Does a country benefit from the R and D carried out in other countries in respect of its trade. If one believes that the major carrier of these spillovers

is trade, *per se*, then this would be a reason to encourage trade. There is a study on the Republic of Korea by the World Bank that has looked at the channels through which firms in that country increased their productivity. The study was based on a questionnaire. According to the answers, around a quarter of the benefits came through the local labour market, essentially through the migration of workers. Benefits from trade were also mentioned. For example, the foreign importer provided producers with extremely useful information about which products were required, how to market them and, sometimes, even manufacturing techniques. Similarly, foreign trading partners advise on improved production and marketing methods.

93. A number of economists are concerned with certain types of trade policy. If one takes the case of non-tariff barriers (NTBs), for example, then some of these can be very harmful in this type of context. If there is competition for the rents generated by these NTBs, then a lot of entrepreneurial talent and energy will go into bidding for these rents, and these are lost resources. Thus, in relatively poor countries, in which this type of talent is scarce, bidding for rents might have very strong effects. Murphy Shleiffer and Vishny discuss this problem. They used a set-up in which people sort themselves into two professions -- engineers and lawyers -- with only the former being productive, to take the extreme case. They do not discuss trade protection as such. They argue that if one looks at a cross-country sample, then countries that have more engineers than lawyers (who have the same basic abilities) grow faster. Let us take the extreme position. They examined a large cross-country sample. It is quite true that if one thinks about the efforts going into bidding for rents generated by NTB, one realizes the amount of lost resources. In some countries, it is quite high and people who can really do a lot of good end up bidding. So, as far as import protection and the like is concerned, one really has to be able to make a strong case for it on an individual basis in order to recommend a policy like this. If somebody comes up with numbers and shows that import protection will do miracles, then one should accept it, but broadly speaking, this just does not seem to be the right policy.

94. There is really a broad issue that is relevant for any United Nations body. We discussed the trade policy issues from the point of view of individual countries and what is good for an individual country. But, one should also think about the entire system, and how it works. With developed economies, on the one hand, and the developing economies, on the other, technology gap models, as simple as they are, and incomplete as they are, are trying to capture the mechanism of innovation and imitation. There is a link between the innovation process in the advanced economies and the imitation of technology taking place in the South. This link is very important because if a system is built in a way that will introduce policies which, on the face of them, look very good for the less developed countries, but will kill the incentive to innovate in the industrial countries, this will not be good for the less developed countries. So, one should not only think about what is good for the individual country, but also in terms of the world trading system. What kind of rules and regulations and policy recommendations can one provide in the system at large?

2. Technology policies in developing countries

95. The literature emphasizes a type of innovation that is not particularly important for developing countries. It may be important for the NICs, but probably not for many other countries. Therefore, there is a need to focus on aspects of relevance to the majority of the less developed countries. There, the main issue is how to raise the domestic productivity by essentially building technological capability and capacity to assimilate technologies and knowledge which are available in the world. This is the main problem to be dealt with. It is cheaper for them to assimilate available knowledge rather than trying to generate their own knowledge.

96. Nevertheless, in order to achieve this goal, it is necessary to develop their domestic base and this is where the focus of technology policy should be. The development of this base involves the development of a suitable infrastructure, both physical and organizational. A broad educational system is required which will generate people capable of operating in this environment as well as the development of skills and technological knowledge in specific areas in order to absorb and adapt existing technologies. This is already a tall order, involving a lot of work and in fact, a variety of policies which may take many years to materialize. What will this lead to? It should lead to the development of a manufacturing base. This may have major effects on agriculture which

should not be discounted. What are high-tech goods? Are potatoes high-technology goods? Well, they might be. There are countries in which agriculture is high-tech and one can make major productivity gains in agriculture by using technology. There are many countries in which the productivity of agriculture is very low and if one could increase the productivity of agriculture, it would be a major achievement. So, one should not only look at computers and chips, but also many broad areas of economic activity in which major productivity gains can be achieved by assimilating existing technology, and perhaps adapting it to local use. All this requires a knowledge base which is not available in many of these countries. Thus, there are major areas of policy on the importance of which there is widespread agreement. These should not be discounted.

97. What are the additional areas in which the government can operate? Policies should be market-friendly and public servants and the administration in these countries should also be business-friendly. Often, if one tries to form a company in a less developed country, the administrative procedures are formidable and this is a major obstacle to the formation of business enterprises in these countries.

98. This is quite simple and everybody will agree. However, it is a major problem in many of these countries. If developing countries develop the skills and technologies and have wonderful research institutes, but companies cannot be formed, this would be a big waste. Once this is accomplished, I think probably 90 per cent of the job has been done. Nevertheless, there is the remaining 10 per cent which might be quite important. In most countries, there is a need to centralize to some degree the accumulation of information that is available in the world and make it available for domestic use. It is probably not very wise to expect every economic unit to do the information gathering on its own. People from developing countries study abroad and avail themselves of this information, but when they get home, they become essentially isolated from the international network. The maintenance of this network is critical. Moreover, governments can do quite a bit to centralize the information-gathering activities and make them available for domestic use. A variety of institutions, government agencies and the like are needed, although this does not mean that the government itself has to be involved. It has only to organize these activities. This is important, especially since many of these countries move into high-tech activities, where constant changes take place and they therefore need to be kept informed of changes and new processes becoming available.

99. Another question concerns the manufacturing base, and here I will include agriculture in manufacturing, since agricultural production is also manufacturing in respect of technology. The evolution of this type of base generates agglomeration effects. One really big issue is: "How can the government support or not disturb the evolution of these interlinked activities"? Now I want to make one distinction between developing economies and the United States or the EEC. Companies and factors move easily across states in the United States, whereas there are much fewer footloose factors of production in less developed countries. It is not so easy to move in and out of a country. One big advantage of this is that if agglomeration effects produce rents, they get dissipated to local factors of production to a large extent. This is what the government should try to achieve because the increase in the income of the local factors of production is just a reflection of the productivity gains. So this is desirable. There is a question of how to do it. On the list of questions provided by UNCTAD was: "Is it good to have state enterprises?" My answer is no, probably not for this purpose; at least, not given what is known about state enterprises. This brings up serious time-consistency issues. State enterprises generate serious time-consistency problems in policy implementations. It is not clear that the benefits of having state enterprises outweigh the benefits of having private companies in this area. Even in electricity-generating activities, telephone networks, postal services, etc., there are many countries which switched from public enterprises to private enterprises, but the latter are then regulated of course. So, the issue is how to regulate this type of enterprise efficiently rather than trying to form public enterprises and getting involved in the difficulties that many countries have encountered so far. In this entire area, there is quite a lot that governments can do. But again, this does not concern so much trade policy but domestic industrial policies.

100. If all this is to work, one needs a suitable competition policy and the example of Malaysia and the way it is reducing tariffs is a very good example of how to introduce competition policy effectively and in a way which is not disruptive. Some other countries have followed a similar path. Israel, for example, has a system with various phases of tariff reduction, one now underway being spread over a seven-year period. Then, there are free-trade policies that can be adopted which also operate like competition policies. Thus, to use administrative regulation to prevent concentration

in an industry is not necessary if there is enough competitive pressure from other sources, and particularly from foreign sources. One might even want concentration, provided that one has got a lot of competition. If one takes the example of a small country that develops some capability in a sector which requires large companies, there is nothing wrong in it. They might have two or three companies in this sector, but one has to make sure that there is a proper competition policy.

3. Technology leader and follower issues

101. As a rule, even to promote innovation, some degree of competition is needed; the question is really: "How much?". That is, what type of trade policy will work? So, let us look at some extremes and see what happens. Assume that an industry is dominated by a single firm and the government gives protection to the industry. Will this firm innovate? How much will it learn? The incentive for it to innovate is very small. In fact, it will typically have less of an incentive to innovate than another company that is not in the market at all. For example, a Brazilian single company, *when it calculates the incentives*, looks only at the incremental profit it intends to gain.

102. Thus, preventing competition altogether harms the process of innovation and technical progress. So, it should be clear that some degree of competition is needed. Conversely, it is not advisable to generate so much competition that all the private benefits are eliminated from innovation because there would be no innovation whatsoever. This is the other extreme and would not be helpful for technical progress. Some protection of intellectual property rights is necessary in order to have some incentive to innovate. So, there is a policy dilemma. It is difficult because the right balance must be found.

103. For example, Brazil is a big economy and, therefore, one would think that it has a big market, and if it protects its industries, they could bloom in this market. In fact, they did not, because they were highly concentrated industries with little outside competition. They did not innovate much. They did not improve their technologies. They did not have good incentives. They did not perform well under an import substitution framework. This fact has to be borne in mind. Another example is the Japanese car industry. Many people have the impression that MITI essentially led the Japanese car industry into the ranks of the multinationals. The fact is that MITI tried to prevent competition in the Japanese car industry. But despite MITI's attempts to restrict entry, new companies succeeded in entering the car industry. There was more competition in the industry so that they began to generate high productivity. There are many other examples. Assume a two-country world, competing in a technology race in some industry, and it is in the nature of the industry that past experience helps future innovation. In this type of industry, it is easy to construct examples where the country that has the technological lead widens its lead, and ends up winning the technology race. The next question is: "Does this mean that the country that did not win the technology race is in bad shape"? Not necessarily, because, if they can import the goods concerned, then they import them at a lower cost and they benefit through trade. So, the critical point is that they should maintain an open trading system. If they maintain an open trading system, they benefit from the innovations made by the technology leader. The fact that a country is the technological leader is not necessarily bad for the other country. In this case, from the point of view of world efficiency, it is definitely better for the initial leader, who has the advantage in R and D, to just go on and innovate. This is the efficient outcome. This means that, from the world point of view, assuming all countries maintain an open trading system, there is an efficient solution. However, some problems arise.

104. One question is what happens if the trading system breaks down, for whatever reason. Countries then get locked in whatever position they are at the point of breakdown. If a country did not develop certain technological sectors, then suddenly it has to face enormous prices for these products. So, the danger of the collapse of the trading system generates problems and this might be a good reason to maintain some capacity in some sectors or stocks. The other problem that arises is that these types of processes need to be income-neutral. So, the follower country does benefit, but the question is: "Could it benefit more by engaging in some sort of a policy"? One possibility would be, for example, to promote the sector to begin with, hoping to win the technology race. Then, the follower does not face the danger of the effects of the possible collapse of the trading system. The above means that each of these courses needs to be weighed against the

other. One cannot say, *a priori*, what is the best thing to do. In fact, there are some other considerations which have to do with the capital markets. To finance the process of innovation, capital is needed. Assuming access to international capital markets, roughly everybody faces the same cost of capital. If there is some segmentation, as is most often the case, then in the countries with less developed financial markets, the cost of capital to enterprises is higher. Thus, the enterprise in the follower country ends up at a disadvantage, even if, technologically speaking, it might have an advantage. So, there is a whole range of issues that the theoretical models have not addressed, but it is quite clear that these issues exist and have a bearing on the problems at hand. The above are really, however, mainly problems of the developed economies, except for the capital market problems. For developing countries, most of the concern should be: "To what extent does a country benefit"? or "can a country benefit from whatever is already available in the world economy"?

105. Developing countries can draw on knowledge, technology and innovations in a variety of ways. To begin with, developing countries can import goods at a low price and there is no reason why they should not trade. Closing their economies from this point of view is really not a very good idea. The other point is that, in order to benefit from these sources, it is necessary to have a domestic capacity. There are limits when a labour force has four years of formal education. So, there are obvious steps that a government can take in this respect. The educational system is critical. It is critical to provide infrastructure, not only roads, but also technical education, a telephone system, a communication system, etc. One can do little without it, and many developing countries just do not have it. So, there is plenty to do in these areas. Now the question is: "Is it really useful to target a particular industry in this respect"? This is a critical situation for which there are really no answers. In principle, the answer would be "yes", but in practice, it is hard to find the way.

4. Responding to technological protectionism in the North

106. Increased world protectionism is a possible scenario, but overall, it is a temporary phenomenon. It is a temporary phenomenon because the recession is temporary and will not last forever. Although there are serious structural problems in Europe, those will be resolved in the next few years and this protectionist mood can change as well, i.e. it is not something that will last forever in the United States and in Europe. But the main concern of developing countries is whether they should move away from open economy policies.

107. I do not see much change in the principles, and one should not take the attitude that the system is going to close down and nothing can be done about it. A lot can be done about it and definitely one should argue against the current trend of protectionism. The other point is that, indeed, the South can still rely heavily through trade on the knowledge and technology available in the North. Of course, developing countries will benefit less if they do not have access to the developed market-economy countries' market. There is, of course, the possibility of interaction among the Southern economies themselves, i.e. they can trade more with each other. There is much more scope for enlarging trade among these economies, especially if they grow. This does not include necessarily only the less developed countries, but also some other countries in the region. Thus, even if the current trend continues in North America or Europe, it does not mean that the type of policy discussed here should be changed. The policies will, however, definitely be much less effective. The question is not whether the South should become more protectionist if North America and Europe raise other trade barriers or refuse to dismantle current ones, but whether it is good for the South to become more protectionist. Overall, I do not see how anyone benefits by becoming more protectionist. The only reason for such a policy might be that it is viewed as a strategy intended to bring about the dismantling of protection in the North. This is the only way that increased protection by the South would be beneficial. Otherwise, developing countries do not stand to gain by just raising tariffs and putting up other impediments to trade. This would lessen competition in these countries. Even through imports there is a lot of transfer of technology and knowledge that can come about. For example, what would happen to capital goods if developing countries raise general protection? Will they start importing less capital goods? What about intermediate inputs? Would protection then be restricted only to some goods? Would it not spill over to other things? So, it is a very dangerous road to take and should be approached with cau-

tion. In each case, one should only consider the question: "Is it good for the South to engage or not to engage in retaliatory policy"? If, by engaging in a trade-war, it is believed that the impediments to trade can be dismantled, then one should do it. However, I do not think that this will work.

By

Yoo Soo Hong

108. It seems to me that the main theme of this workshop is trade and technology with the premise that technology is the core of international competitiveness. If this perception is correct, it is quite natural to start with a review of the technology-gap literature. Since benefits from technological development are not restricted in trade promotion, I feel a little uneasy confining our attention to the role of technology as the only engine of international competitiveness. I do not deny that more and more countries have become aware of the importance of technology in international trade and been persuaded to use technological policies and strategies to enhance their positions in the world market. However, I believe that benefits from technologies are complex and that separating the role of technology in promoting international competitiveness from other benefits such as national security, environmental protection, health care, and world-wide communication and transportation networks, may result in extremely biased and unbalanced development of technological systems of individual countries and the world as a whole.

109. With this caveat, I will discuss the issues at hand, one by one, in the following order. First, I will comment on the survey of the technology-gap literature prepared by Mr. Alessandro Goglio.[1] The survey is extremely well organized, lucid and profound, so that I do not have much to say on the survey itself. Rather, I would like to point out the weaknesses and drawbacks of the main stream technology-gap literature as reviewed by him. Despite its invaluable contribution to the understanding of the relationship between technology-gap and trade performance, focusing on the interaction between the North and the South, the literature has neglected the treatment of the mechanism of technology transfer from the North to the South. This criticism applies even to those models of endogenous technology-gap. The literature has also neglected the fact that the North can collect revenues from technology transfers to the South by focusing only on the monopoly rent from its exports to the South.

110. Most of the technology-gap models have assumed that transfer of technology is cost-free and exogenously determined, although a few models with endogenous innovation and learning have included transfer costs. There are at least four channels of technology transfer: licensing; transnational corporations (TNCs); trade of technology-embodied capital goods; and collaborative research, including exchange of scholars, experts, students, scientific journals, etc. These channels often overlap. The point is that all of these require substantial amounts of resources which are transferred from the South to the North.[2] These amounts should be considered for the discussion of welfare implications of technology-gap. As mentioned previously, the North not only collects rents from its exports to the South, but also collects revenues from exports of technology-embodied capital goods, royalties, remuneration of TNCs which includes the rewards for transferring know-hows and technologies.

111. If the technology-gap models explicitly recognize and incorporate these revenues, the increased speed of technology transfer may not necessarily reduce the welfare of the North. If the speed of technology transfer depends on the revenues from the transfer, then the speed itself can be determined endogenously. Today, the most serious problem in technological development facing newly industrialized economies (NIEs) is the ever-increasing costs of technology transfer. In the case of refusal by a developed country to transfer a specific technology, the transfer cost of that technology becomes infinite.

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1 UNCTAD, "Technology-gap theory of international trade: A survey", Geneva, United Nations, 1991. See also annex I above.

2 For technology transfer mechanism and cost, among others, see David J. Teece, *The Multinational Corporation and the Resource Cost of International Technology Transfer*, Cambridge, Massachusetts: Ballinger, 1976; Farok J. Contractor, *International Technology Licensing: Compensation, Costs and Negotiation*, Lexington, Massachusetts: Lexington Books, 1981; Bernadette Madeuf, "International technology transfers and international technology payments: definitions, measurement and firm's behavior", *Research Policy*, 13, 1984, pp. 125-140.

112. An increasing number of industries in NIEs are exposed to the decision-making problem of "buy or invent". The trends are in the direction of increasing national R and D expenditures for self-sufficient technological development as technology protectionism by developed countries has continuously increased. Models of endogenous technology-gap treat the resource requirement for innovation and imitation. However, this treatment is still unsatisfactory, since the the models do not examine the process and cost of technology transfer. An exception to these comments is Pugel, who explicitly treats the role of technology-transfer cost and observes:

> "The welfare of the home country is lowest in a world of no transfer, improves with free transfer, improves with globally optimum royalties, and improves further to the nationally optimal foreign royalty, the highest possible. The welfare of the foreign country is lowest in a world of no transfer, and this presumably is equivalent to the welfare achieved under the highest royalty possible. Free transfer is better. The highest welfare is achieved under its nationally optimal foreign royalty, which may be either zero or positive and is less than the globally optimal royalty. Thus, the basis for bargaining over the actual foreign royalty rate is clear. The transferring country prefers a high rate, and the recipient country a low rate".[3]

The future works of the technology-gap literature should be in line with an approach simular to Pugel's from which more realistic and reasonable policy implications can be derived.

113. Another drawback of the technology-gap literature is, as correctly observed by Mr. Goghlo, that the South in the literature does not cover the entire range of developing countries, but only the major developing economies (MDEs). More work is needed to extend our knowledge of the interaction between the North, MDEs and non-MDE developing countries. Leaving this aside, I will next focus on the technology policies in MDEs.

114. One of the policy issues of this workshop is uncovering the obstacles or market failures that justify government intervention to promote the private sector's technological capabilities. First, the technological change of a firm generates positive (or negative) externalities and spillovers to other firms and to the consumers of the product produced by the generated technology. Usually it is difficult for the firm to appropriate all the benefits to society of the technological change it created. Secondly, technological innovation is subject to great uncertainties. Thirdly, technology has the public good character of non-rivalry. Fourthly, physical infrastructure and institutional infrastructure and providing a favourable environment conducive to technological innovation often require huge amounts of investment or political power which are beyond the ability of individual firms. This is truer in the infant-industrial stage of development.

115. The second topic of this workshop seeks to identify the extent of policies encouraging technological development without producing distortions or disequilibria elsewhere in the economy. The first point I would like to emphasize on this issue is that not all the activities of technological development are the responsibility of the private sector, although the role and importance of the private sector have tended to increase in most MDEs. In the areas already pointed out above, the interventions of the government do not necessarily result in distortions or disequilibria in the economy. On the contrary, there is an improvement in the efficiency resource allocation. The second point is that factor and product markets are usually underdeveloped and imperfect in the developing countries.[4] Furthermore, markets for technology are far from competitive. Thus, government intervention usually aims at the second or third best policy achievement rather than the first best.

116. For each technology, the decision is "buy or invent". However, for the nation as a whole, the decision may be "buy and invent", since technological development is dynamic and accumulative. That is, a developing country should not only acquire foreign technology, but also develop its own technological capability over time. Technologies change constantly and so do the requirements of a country at different stages of technological and economic development. Accordingly, policy priorities and instruments should vary over time. Because developing countries vary widely in endowments, stages of development and industrial structure, it is rather difficult and dangerous to draw common principles of technology policies applicable to all. However, the following few points are made in an attempt to consider technology-related policy implications for developing countries.

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3 Thomas A. Pugel, "Endogenous technological change and international technology transfer in Ricardian trade model", *Journal of International Economics*, 13, 1982, pp. 321-335.

4 Joseph E. Stiglitz, "Market, market failures and Development", *American Economic Record*, May 1989, pp. 197-203.

117. In the process of international technology transfer, the government can intervene with various policy instruments. Since the price of technology is not determined by the competitive market principle, but by negotiation, the role of the government is to provide the best institutional environment in which transferers and transferees can reach the best terms of trade and ensure that the most appropriate technologies are transferred. The government in a developing country should adopt policy instruments and institutional arrangements that maximize local transferees' bargaining power and, at the same time, foreign transferers' willingness to transfer appropriate technologies at a desirable speed. Obviously, this is a difficult job requiring both experience and a wide range of information. As long as a developing country's government achieves these policy objectives and the net social benefits are positive, the policies enhancing local transferees' bargaining power may not necessarily result in serious distortions or disequilibria elsewhere in the economy.

118. The problem is that technologically advanced countries tend to undertake strategic partnering,[5] collaborative research and technology transfers among themselves as a means of protection against those developing countries which succeed in entering their markets.[6] Faced with this problem, governments of developing countries have increased their role in enhancing indigenous technological capabilities. The enhancement of indigenous technological capabilities in itself contributes to strengthening the country's bargaining power in the process of technology transfer.

119. On the basis of "buy and invent" decision for technological development, a set of policy instruments enhancing indigenous technological capability of a developing country can be identified. I do not see any fundamental difference in the role of technology policies between developed countries and developing countries. All those policy instruments classified by Rothwell and Zegveld[7] can be used by a developing country government (see table). Among these policy instruments, financial instruments such as loans and subsidies and taxation schemes easily tend to facilitate the creation of distortions and disequilibria. Government procurement, public enterprise, government's scientific and technical activities also tend to generate distortions, but to a lesser degree. Carefully designed categories of policy instruments such as education, information, public services, etc. can avoid distortions. The extent to which distortions and disequilibria are generated by each policy instrument and are accepted depends on the specific circumstance of the country and the objective of the policy. Often, a certain degree of distortion is unavoidable due to conflicts between policy objectives and instruments. When the main objective of the policy is to reduce distortions, the government should explore the avenues that strengthen and expand less distortive measures such as education, training, information dissemination, public procurement, non-proprietory basic research by universities and public laboratories and international technological co-operation. At the same time, in the areas of development of commercial technology and production of technology-intensive goods, the government should make efforts to obtain the optimal market structure[8] for R and D competition as well as product competition.

120. It is not only unrealistic, but also erroneous, to draw a line for each policy instrument in terms of the degree of distortions it generates, particularly in developing countries where failures of technology markets are the rule rather than the exception. Thus, one should rather focus on the objective and the long-run effects of a particular policy and try to understand the technological system of a country as a whole, in which the private sector is just a part, but one with a rapidly expanding role. Supporting the observations made and views taken by Nelson,[9] I would like to emphasize that countries differ in their belief about the appropriate roles of government in technological development and that there are no simple rules of policy evaluation.

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5 A good observation of this is found in L. Mytelka Krieger (ed.), *Strategic Partnerships: States, Firms and International Competition*, London: Pinter (1991).

6 See D. Ernst, "International technology diffusion: the challenge for newly industrializing economies", a paper presented at the International Conference on Changing Technology Environment and Policy Responses, Seoul, Republic of Korea, 30-31 October 1991.

7 R. Rothwell and W. Zegveld, *Industrial innovation and public policy: preparing for the 1980s and the 1990s*, London: Pinter (1982).

8 Unfortunately, there is no consensus yet among economists on what is the optimal market structure for optimal technological innovation.

9 R. R. Nelson, "National innovation systems: a retrospective on a study", a paper presented at the International Conference on Changing Technology Environment and Policy Responses, Seoul, Republic of Korea, 30-31 October 1991.

121. In order to reduce the currently growing tensions and antagonism in the areas of trade and technology between developed and developing countries, it is both desirable and necessary to develop general rules and principles for technology policies applicable to all countries. However, it will certainly take much longer than expected to reach a consensus on such rules. The first rule, if any, to be agreed upon will be that maximum flexibility should be given to the application of those rules to individual countries.

Table

Classification of government policy tools

	Policy tool	*Example* [a]	*Distortion effect* [b]
1.	Public enterprise	Innovation by publicly-owned industries, pioneering use of new techniques by public corporations	variable
2.	Scientific and technical	Research laboratories, support for research associations, learned societies	low
3.	Education	General education, universities, technical education, retraining	low
4.	Information	Information networks and centres, libraries, advisory and consultancy services	variable
5.	Financial	Grants, loans, subsidies, financial sharing arrangements, provision of equipment, buildings or services	very high
6.	Taxation	Company, personal, indirect and payroll taxation, tax allowances	high
7.	Legal and regulatory	Patents, environmental and health regulations, monopoly regulations	low
8.	Political	Planning, honours or awards for innovation, encouragement of mergers or joint consortia	variable
9.	Procurement	Central or local government purchases and contracts, public corporations, R and D contracts	variable
10.	Public services	Purchases, maintenance, supervision and innovation in health service, construction, transport, telecommunications	low
11.	Commercial	Trade agreements, tariffs, currency regulations	high
12.	Overseas agent	Defence sales organizations	low

Source: Adopted from Rothwell and Zegveld (1982).

a Selected by the author from the original table

b Evaluated by the author

By

T.N. Srinivasan

122. Let me at the outset say that the technology gap models, so ably reviewed by Mr. Alessandro Goglio, are of extremely limited relevance in formulating technology policies for many units, if not most developing country economies. There are several reasons behind this assertion. First and foremost, agriculture and primary production account for the major share of employment and a smaller, but still dominant sngle-sector share in value added in these countries. Agricultural technology (though not necessarily that of all primary production) is quintessentially location-specific for obvious reasons -- the heterogeneity in soil quality and large variations in agro-climatic conditions even within small regions. Simplistic processes of technology transfer and or imitation as formulated in product-oriented technology-gap models are clearly irrelevant in thinking about policies to encourage the development of location-specific crop varieties or cultivation practices that would raise total factor productivity. While it is true that the importance of this sector would decline with rapid development, it is fair to say that for many developing economies for the foreseeable future it will continue to be important. Second, the production of goods and services that are not or cannot be traded internationally constitute a second important sector in developing economies with respect to which most of the extant technology-gap models are of limited relevance, once again for obvious reasons. In the North-South models, the competition in the goods market between Northern and Southern producers is important. In the Jensen-Thursby technology-gap model, which has a non-traded sector, it has no direct role in technical change, but only an indirect one through its competition for labour with the manufacturing sector that develops and produces new goods. Yet, if economic historians are to be believed, innovations that, broadly speaking, reduced transaction costs of economic exchange, whether they are related to transport and communications or to institutions such as the system of property rights, legal system as well as conversions and usage as they relate to contracts and their enforcement or to the process of human capital accumulation, have been the driving force behind the development of contemporary developed countries. Needless to say, most of their activities fall in the sector of non-traded goods and services. Third, the important distinction between process and product innovations is blurred, if not altogether absent, in the technology-gap models. While it is foolish to be categorical about matters on which solid empirical evidence is scant, I would venture to suggest that perhaps process innovations are likely to be more important from a development perspective than the product innovations that are the centre of most technology-gap models. Fourth, in some, if not all, of the technology-gap models, the advantage of the North in innovation is an assumption (rather than a description of the autarky equilibrium in the North and South) and the focus of analysis is the effect of potential southern imitation on northern innovation and the competition in the goods market in a two-country world. One could argue that this analytical focus is far less interesting, and perhaps less relevant from a policy perspective, than an exploration of the determinants of northern advantage. Fifth, it is not at all evident and, to the best of my knowledge, the empirical evidence on this is ambiguous, that the Schumpeterian conjecture of a positive association between market concentration and innovation, is well-founded. It is arguable, and anecdotal evidence supports the argument, that many technological innovators of major significance were small actors, at least when they innovated in the markets radically transformed by their innovations. How market concentration is viewed from a technology policy perspective would depend on the empirical significance of the Schumpeterian conjecture.

123. With these sceptical remarks about the relevance of technology-gap models to policy-making in developing countries out of the way, let me turn to each of the issues for discussion as raised in the UNCTAD note. I will take them seriatim.

Topic 1: ***Implications of technology-gap theories***

124. It is not obvious to me that the most fruitful interpretation of the technology-gap models is that 'dynamic' comparative advantage (whatever it means in a precise sense!) 'drives' them. Even if it does, there is no necessary implication of a greater scope for government intervention than

would be the case were 'static' comparative advantage to be the driving force. As long as welfare by nationals is the government's objective, any argument for intervention has to be based on its potential for improving welfare over the non-intervention situation taking into account the reaction of all those likely to be affected by the intervention, including the governments of trading partners. These reactions, which should include legal avoidance and illegal evasion of the intervention, depend, in particular, on the structure of the relevant markets as well as the distribution of the relevant knowledge and information among those affected. The literature based on oligopolistic market structure has made it abundantly clear that policy inferences from it are extremely fragile rather than robust. Changing the assumption, for example, about the nature of competition from Cournot to Bertrand can change the nature of policy intervention in some simple models from a subsidy to a tax. If the assumption is to have consistent conjectures about the others' equilibrium response to one's own action and behave accordingly, even the need for intervention disappears altogether. Furthermore, the literature on rent- and revenue-seeking that are triggered by policy intervention shows that intervention could end up worsening rather than improving welfare compared to the no intervention situation. Thus, whether or not the possibility of welfare-improving interventions exist cannot be determined from *a priori* considerations, but only from a case-by-case empirical analysis. The literature offers few such analyses. However, numerical simulations from imperfectly competitive models of international trade do not indicate large gains in welfare from strategic policy intervention. Although these simulations are based on static models, I would be very surprised if similar simulations with dynamic models yielded much larger welfare gains.

125. I have pointed out above and repeat here that the structure of production and demand in many developing economies make it extremely unlikely that technology imitation *à la* technology-gap literature would be their yellow brick road to development nirvana !

Topic II: ***Pervasiveness of market failures***

126. Samuel Johnson's dictum that patriotism is the last resort of the scoundrel can be paraphrased to say that an appeal to pervasiveness of externalities and market failures is the only resort of *dirigiste* development economists, bureaucrats and international agencies! I have not come across any empirical studies suggesting that such failures are ubiquitous though I would readily concede that environmental degradation is one area where such a failure is likely to be significant. But then it is not necessarily the case that this failure is more serious in developing rather than developed economies.

Topic III: ***Extent of intervention***

127. I would argue that the possibility of government failure has been shown to be serious enough in many developing countries to re-examine the case for, and the character of, government intervention. If the secondary welfare loss due to failed or thwarted, evaded and avoided intervention is likely to be much larger than the primary welfare gain from intervention, obviously intervention is counter-productive. For example, a theoretical case for optimally differentiated commodity taxation in the assumed absence of evasion and avoidance (the ease of which can depend on the commodity being taxed and on the rate of the tax), would have to be re-examined if they are in fact present. Once again what are needed are many more carefully done empirical studies. Far be it for me to say that theoretical analyses of the issues of mechanism-design that take into explicit account incentives for evasion, shirking, etc. are not insightful; only that the allocation of research resources has so far been too heavily weighted in favour of theory.

128. It should also be pointed out that it is not as if governments have so far refrained from intervening ostensibly to promote technological advancement. Nor is it the case that public resources devoted to promoting research and development are negligible in many developing countries. The interesting issue for careful empirical research is to probe deeply into why the interventions and the resources spent have not apparently proved as fruitful as hoped.

Topic IV: ***Forms of intervention***

129. At the risk of sounding utterly naive, let me express some scepticism at the facile assertions that the co-ordinating and facilitating role of MITI, or of government contracts for defence-related products in the United States, is the major contributing factor for the apparent success of Japanese export industries (automobiles and electronics in particular) and the aerospace industry in the United States. It is clear that if a sufficient volume of resources and effort are together devoted to a particular industry, it can be developed, as for example, the European Airbus or the Brazilian aircraft Bandarante. What is not so clear is whether the expenditure of resources had a benefit cost ratio (BCR) that exceeded unity, let alone exceeded by a margin the BCR of potential alternative uses for the same funds.

130. Some observers have suggested that what distinguishes the Republic of Korea (and Japan) from other countries is not that the governments of the two countries intervened in the economy, but the fact that the governments were willing to withdraw or scale down interventions if they turned out to be ineffectual and inconsistent with the market signals where appropriate. Thus, with the credit and other subsidies came an explicit threat that they would be withdrawn if the industry could not become internationally competitive. This is in contrast to made-to-measure indefinite protection virtually guaranteed to import-substituting industries in India regardless of their performance.

131. There is no strong evidence to suggest that the bureaucracy has better information than the market in picking sure winners among alternative foreign technologies to import. Even if it did, it would probably be better to make information freely available rather than attempt to make the choice itself. Nor need it necessarily be the case that bureaucrats are better negotiators or less corrupt in dealing with foreign firms. Experience in some developing countries suggests that attempts by the bureaucracy to guide negotiations with foreign firms, screen foreign direct investment proposals and set performance and technology transfer requirements on those foreign firms permitted to invest have merely delayed foreign technology imports and scared away direct foreign investment rather than improving their quality, appropriateness and volume.

132. Setting a fixed duration for public-sector operation of enterprises in the so-called strategic industries, in which private investors do not find it fruitful to invest, is more easily said than done in many developing countries. On the contrary, far from divesting a state enterprise once it gets going as a commercially viable operation, the tendency is often to take over failing private enterprises ostensibly to protect employment. In some egregious cases, the society would have saved resources if those enterprises had been shut down and their workers been guaranteed lifetime incomes. Protection and subsidies (producer or consumer) once granted, become entitlements which are politically difficult to withdraw.

133. Successful co-ordination by government requires an information flow that is reliable and timely. Otherwise, co-ordination may simply result in all those industries or entities affected rapidly moving in unison down the wrong path until it is too late to change course. Under these circumstances, lack of co-ordination could be a virtue -- mistakes in different decisions could be offsetting or could be realized sooner.

134. Finally, intellectual property rights protection, to the extent it confers monopoly rents, has to be carefully compared with the potential benefits in terms of greater innovation activity. I would venture to guess that both the losses to intellectual property owners from the lack of such protection and the benefits of more rapid innovation would be found to have been exaggerated were careful empirical studies done.

Topic V: ***Technological protectionism in the North***

135. Needless to say, protectionist threats from any quarter have to be met. However, two points are worth making. The first is that the most effective challenge to Northern protection that the South can mount is to offer to forego the crumbs from the rich man's table such as GSP, special and differential treatment, etc. and to observe all GATT provisions. In return, the North should be asked to dismantle the Multi-fibre Agreement (MFA), roll back other tariff and non-tariff barriers to Southern exports and to agree to cease and desist from unilateral actions such as under Section 301 of United States Trade law or its counterpart in other Northern countries. Secondly, it must be recognized that, in spite of Northern protection and fears of its future escalation, Southern exports in Northern consumption use, particularly of manufacturers, has increased

steadily. This is not to say that it would not have grown more with less protection but only that a sense of proportion is needed. Regional integration within the South where conditions are propitious would undoubtedly help. But it is no substitute for a liberal global trading system. One can only hope that the Uruguay Round will deliver such a system.

136. Let me conclude by saying that what is needed is not yet another theoretical rationale for government intervention in the fond hope that it will succeed where many others, in practice, have failed or been deleterious. What are needed are carefully done empirical studies that would identify circumstances where welfare-improving interventions are likely to be feasible in practice.

By

Joseph E. Stiglitz

137. Models that incorporate the creation of new products and processes, and the diffusion of that knowledge, are essential for understanding trade patterns and trade policies.

138. What is distinctive about these models is: (a) the pace of innovation (and imitation) is endogenous; and (b) trade patterns are determined by differences in technological capabilities (rather than differences in factor endowments, as in the HO model). Formally, the distinction may not be as great as it might seem, since those with different knowledge can be treated as a different factor.

139. Policies naturally focus then on: (a) what affects the pace of innovation; and (b) what affects differences in "technological endowments".

The standard models

140. In the following paragraphs, I give my impressionistic reactions to several of the standard models. I do not have the models at hand, and accordingly, I risk misrepresenting them, certainly in detail, but possibly even in spirit.

141. Most of the models I have seen (and described in the technology-gap literature review) focused on only one way by which technology gets transferred from the North to the South, through imitation (reverse-engineering). An equally (perhaps more) important manner is through multinational corporations.

142. Economies in which technological change is important have pervasive externalities. Those innovating seldom if ever capture all of the returns to their innovative effort. The reasons for the discrepancies have been extensively studied elsewhere.

143. Recognizing this has two important implications: policies may affect the fraction of benefits which the innovator captures (equivalently, the externalities, the uncaptured benefits). When the innovator captures less, his incentives to undertake research are reduced. And in deciding the nature of his research programme, he only focuses on the private benefits which he captures, not the external benefits. If one programme had slightly lower private benefits, but much greater externalities, he would still undertake the former programme.

144. Accordingly, governments may want to encourage programmes in which external benefits are larger. A turnkey highly-intensive chemical plant may have low external benefits, relative to a small-scale engineering firm. Ascertaining the extent of "linkages" or external benefits should be an important part of any industrial policy.

145. The technology-gap models explored all involve full employment, with limited alternative opportunities for resources. Policy effects (or parameter changes) result, as I see it, primarily through supply-side effects. Factor prices must adjust so as to make demand equal to those supply-side adjustments. Thus, more rapid imitation by the South leads to less production of goods in the North; labour freed from production can specialize in R and D, increasing the pace of innovation.

146. These problems are always set in a world of second best, since returns to innovation are never fully appropriated. Thus, it is possible that there exist welfare improving policy interventions. Ascertaining whether that is the case is a more subtle matter, because of the complicated dynamics arising in these models. Typically the models focus on steady states, which are good benchmarks for descriptive analysis, but can be particularly misleading for welfare analysis, as the earlier literature in trade and growth (e.g., Stiglitz (1969)) made abundantly clear.

147. The peculiar nature of these supply-side responses can be made apparent by considering a slightly different model, one in which, within the North, there are two types of workers, production workers who produce goods and researchers who innovate. Workers of one type cannot perform at all the activities of the other. Then an increase in the pace of imitation in the South necessitates a lowering of the wage of the production workers in the North. I have not worked out the details, which may depend on the precise specification of the model. Since the resources to be devoted to R and D are fixed, the pace of innovation will remain unchanged. Since the pace of innovation is unchanged, the North will produce fewer goods (the goods which have not yet been imitated), but more of them. To induce people to buy these goods, prices will be lower and to break even, wages will have to be lower. Innovators must find it worthwhile to innovate; they obtain a return on their innovation for a shorter period of time and they charge lower prices; but wages have fallen. Wages of researchers and wages of production workers both fall to ensure that the necessary profit maximization conditions for production and research in the North are satisfied.

148. The South, meanwhile, is better off because it can buy goods from the North more cheaply; wages in the South rise, but so do prices.

149. These are the short-run responses. There can be longer-run responses, in response to the change in the relative wages between research workers and production workers in the North. If R and D wages are reduced more than proportionately to production-worker wages, then we would expect a decrease in the supply of R and D workers and a corresponding decrease in the pace of R and D.

150. The literature as it has developed makes a possibly important point: a decrease in intellectual property rights (allowing the South to more easily imitate the North) may actually lead to more innovation because of general equilibrium effects. The "partial" equilibrium analysis would have emphasized that inventors appropriating a small fraction of the returns to their innovative activity would be discouraged from innovating.

151. Whenever general equilibrium results and partial equilibrium results differ in the dramatic way they do here, we must be circumspect. Are there alternative general equilibrium models more in accord with our intuitions?

152. What would happen, for instance, if we had a third sector, e.g., services, and those displaced out of production of manufacturing in the North went into that service sector?

153. What would happen if the North, faced with easier imitation, put more effort into making reverse-engineering more difficult, or into specializing in products which could not be so easily imitated, because of the absence of complementary inputs in the South?

154. One has to be equally suspicious about policy conclusions drawn using such peculiar models. Assume, for instance, we enlarge the models considered by allowing for direct investment (multinationals). Implicit in the models is an assumption of a link between the location of R and D and the location of production by the firm doing the innovating. This is increasingly not the case.

155. Then, strong intellectual property protection might encourage a North firm to produce in the South. Such production might, at the same time, yield positive externalities in conveying what is sometimes referred to as tacit knowledge, or more generally, the development of modern industrial work skills. Weakening such protection would discourage such technology transfers for the obvious reason. And because the profits to be had from an innovation increase when the goods can be produced more cheaply, the return to the innovator would also be reduced directly. Thus, if he continues to produce in the South, the returns to innovating are lower because there is a shorter time-span during which he appropriates returns; and if he switches production to the North, his returns are lower, because of the higher costs of production.

156. An interesting approach to the set of issues involving trade and R and D is first to ask what world efficiency would look like. Given the interactions between applied research and production, it is not obvious that all research should be concentrated in the North.

157. This provides us a benchmark against which we can look at policy reforms: some may make the economy look more like this benchmark ideal. We will then be able to infer why some policy may constitute an improvement, e.g., by allowing some aspect of the principle of comparative advantage to hold sway. The study by Gogho (see annex I) was excellent at bringing out these as-

pects.

158. At the same time, we want to make a list of the market imperfections, so that we can see how they are affected by alternative policies. A partial list would include (a not mutually exclusive or exhaustive list):

(a) Failure of innovator to appropriate marginal benefits of innovative activity;

(b) Externalities;

(c) Imperfect competition.

159. The importance of the latter has not, I think, been sufficiently emphasized in much of the trade and growth literature. R and D and learning-by-doing give rise to non-convexities of a kind which are naturally associated with imperfect competition. Dasgupta and Stiglitz (1987) showed that, in a simple learning model, market equilibrium would necessarily be characterized by imperfect competition, except in the extreme case where 100 per cent of the learning benefits spill over to the firms within the country and within the industry, a most implausible case (though one which has played a large role in some of the new growth literature).

160. International agencies face a difficult problem in directing product development programmes in Third World countries. There has always been a concern that for the international agencies, the "price-taking assumption" appropriate to a small country is not appropriate for them. If they encourage rice farming in all countries for which, at current market prices, it is extremely profitable, prices may deteriorate.

161. These effects may be particularly important for industrial commodities where profits are associated with temporary monopoly rents. If only one low-wage country produces widgets, it can make a profit. But if many produce widgets, all with similar wages, the competition will erode profits. Even the workers draw less benefit.

162. In traditional Schumpeterian analysis, capital constraints played an important role. The availability of capital limited the amount firms could spend on R and D simply because these were non-collateralizable assets. Advances in recent years in our understanding of capital markets under imperfect information have put Schumpeter's perceptions on a sounder footing. Unfortunately, capital market constraints seem to have played no role in the recent new growth literature (including growth and trade). There are a few exceptions (see Greenwald and Stiglitz (1990)).

163. This is important for an assessment of the validity of the standard infant industry argument. Critics of the argument claim that if the project will eventually pay for itself, the firm should simply borrow to finance the project. Given the (understandable, endogenous) imperfections in the capital market, this may not be feasible.

164. This is but one example of how financial markets enter into the analysis. Trade policies may affect profit margins and in an economy with capital-constrained R and D competition, the changed profit margins affect the level of R and D and hence the pace of innovation.

165. Much of the new growth literature has focused on the importance of human capital.[1] To speak against human capital is like speaking against motherhood: surely we can agree that more human capital is better. Yet the underemployment of engineers and high-school graduates more generally in many Third World countries suggests that lack of human capital is not the only or main problem.

166. In our earlier discussion, we emphasized that technology is mobile: that most of the technology-gap models assumed that there was really less scope for mobility than was in fact the case. If all that was missing was a small amount of human capital, that would be no problem, for human capital too is mobile.

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[1] There are other peculiarities of the new growth literature upon which I did not wish to focus here. Many versions put a heavy emphasis on aggregate return to scale. We have already commented on the fact that learning-by-doing and R and D give rise to non-convexities at the industry level. Urban agglomerations attest to the importance of returns to scale geographically. But, beyond this, is Luxembourg at a marked disadvantage because of its small size? Is Belgium? Does China have a marked advantage because of its scale? Something is amiss in the formulation. For a fuller discussion of these and other objections, see Stiglitz (1991) (Hahn festschrift).

167. One might say that some types of human capital, like managerial genius, are not so mobile; but their fruits are; and, more to the point, it is hard, if not impossible, to design an educational system that can guarantee the production of such individuals.

168. At the very least, we have to work hard to identify the particular kinds of skills which will help facilitate the transfer of technology to close the technology gap.

169. The application of these models to understanding problems of North-South trade will require more attention to the special features of developing economies.[2] The assumption that resources are fully utilized is, to say the least, questionable.

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2 Work on tax theory and cost benefit analysis applied to less developed countries, using models developed for more developed countries (cf. Little-Mirlees, and most of the chapters of the Newbery-Stern volume) encountered precisely that problem. While traditional tax theory focused on the distortions caused by taxation in the supply of labour, these distortions are hardly the first order effects on which policy analysts should focus, when there already is unemployment of 15 or 20 per cent, or more.

Annex IV

List of experts

Doctor François Chesnais	Directorate for Science, Technology and Industry, OECD
Professor Paul David	Center for Economic Policy Research Stanford University
Professor Giovani Dosi	Department of Economics University of Rome "La Sapienza"
Professor Elhanan Helpman	Department of Economics Harvard University
Doctor Hamzah Kassim	Standards and Industrial Research Institute Malaysia (SIRIM) Selangor, Malaysia
Professor T.N. Srinivasan	Economic Growth Center Yale University
Professor Joseph Stiglitz	Department of Economics Stanford University
Doctor Yoo-Soo Hong	Korean Institute for International Economic Policy, Seoul